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State of Connecticut

REPORT

OF

The Connecticut Agricultural
Experiment Station

FOR THE YEAR 1904

PART III.

FOURTH REPORT OF THE STATE ENTOMOLOGIST

W. E. BRITTON, PH.D.

FOURTH REPORT
OF THE
STATE ENTOMOLOGIST
OF
CONNECTICUT
FOR THE YEAR 1904

BY
W. E. BRITTON, PH.D.
State Entomologist

New Haven, Conn.

1905

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ILLUSTRATIONS.

Fig. 7 from Washburn, Report of Minn. State Entomologist.

Figs. 8, 9, 11 and 14 from Bureau of Entomology, U. S. Department of Agriculture.

Fig. 15 from Felt, Culicidae of New York State.

Figs. 12, 13, 16-20, 22, and Plate XVI, b from Smith, Report on New Jersey Mosquitoes.

Figs. 10 and 21 from original drawings by L. H. Joutel.

Plates V, a, VI, a and XII from photographs by W. E. Britton.

All other plates from photographs by B. H. Walden.

FOURTH REPORT

OF THE

STATE ENTOMOLOGIST OF CONNECTICUT

To the Director and Board of Control of the Connecticut Agricultural Experiment Station:

I hereby transmit my fourth annual report as is required by Section 4387 of the General Statutes. Following the system adopted in previous reports, the period covered is the calendar year of 1904, except for the financial statement, which is arranged to correspond with the State fiscal year ending September 30, 1904.

Respectfully submitted,
W. E. BRITTON,
State Entomologist.

REPORT OF THE RECEIPTS AND EXPENDITURES OF THE STATE ENTOMOLOGIST FROM OCTOBER 1ST, 1903, TO SEPTEMBER 30TH, 1904.

RECEIPTS.

From E. H. Jenkins, Treasurer	\$3,655.17
G. P. Clinton, for mileage	.48
	\$3,655.65

EXPENDITURES.

Field, office and laboratory assistance	\$1,720.87
Printing and illustrations	421.04
Postage	13.49
Stationery	8.25
Telephone and telegraph	3.35
Express, freight and cartage	26.50
Library	311.15
Laboratory apparatus and supplies	552.41
Spraying apparatus and supplies	82.72
Office supplies	8.56
Traveling expenses	374.54
	\$3,522.88
Balance, cash on hand	132.77
	\$3,655.65

Memorandum—This account of the State Entomologist has been duly audited by the State Auditors of Public Accounts.

INSECT PEST LAW.

As there has been no change in the law during the year it is omitted from this report. Persons wishing to examine it are referred to Sections 4386 to 4390 of the General Statutes, or to the Report of this Station for 1903, page 200. Copies of the law will be sent on application to this office.

PUBLICATIONS.

During 1904 the following publications were issued from the entomological department:

Third Report of the State Entomologist (Part III of the Report of the Station) was printed in an edition of 12,000 copies, and distributed in March. This report contains 80 pages, 16 figures and 8 plates.

Bulletin 146, San José Scale-Insect Experiments in 1904, 32 pages, 4 plates, contains the results of the spraying experiments to kill this pest in 1904. Twelve thousand copies were distributed in November. This bulletin in slightly emended form is reproduced in this report.

A press bulletin on the habits, life-histories and breeding places of mosquitoes together with remedial treatment was issued June 13th, and printed in nearly all the newspapers of the state.

A circular giving information about the draining of mosquito breeding pools on the salt marshes was printed in July, and a small number of copies were distributed only to those interested in this work. Circular letters urging work in mosquito control were sent to about 150 proprietors of hotels and summer resorts along the shore, about September 1st.

ORGANIZATION AND EQUIPMENT.

Assistance.—Mr. B. H. Walden has assisted the State Entomologist throughout the year; he has helped in the spraying experiments, has done most of the photographic work and now is in charge of the collection of insects. Mr. Henry L. Viereck was first employed to rearrange the specimens in the collection, but he helped in the spraying work and was continued on the

mosquito investigations during the summer until September 15th. Mr. Viereck examined the salt marsh region of Connecticut from New York to Rhode Island, bred several species of mosquitoes and aided in the general collecting and curatorial work. Both Messrs. Walden and Viereck have aided in preparing this report. Mr. P. L. Butrick, a high school student, was employed through July and August to collect and mount insects. A laborer was employed for a month during March and April to help about the spraying work. Miss Anna Davis Clark was employed as stenographer for part of each day after November 7th. All of these assistants have performed their duties faithfully and acceptably.

Collection of Insects.—The insect collection contains about 20,000 named species and 15,000 specimens of Connecticut insects; 7,000, or nearly half, were additions made during 1904, and which have not yet been identified. The whole collection is now in Schmitt boxes enclosed in metal cases, which is a safe method of keeping the specimens.

Library.—The library of the entomological department has received several additions during the year. Chief among these are complete sets of the Proceedings of the Entomological Society of Philadelphia, 1861-1867, 6 vols.; Bulletin of the Brooklyn Entomological Society, 7 vols.; Papilio, 4 vols.; Riverside Natural History, 6 vols.; Forstinsektenkunde, by Judeich and Nitsche, 2 vols., and a number of reports, monographs and single volumes.

A set of the cards pertaining to entomology, published by the Office of Experiment Stations, has been bought and arranged for ready reference.

Microscope.—A new Bausch & Lomb microscope outfit with one-twelfth oil immersion objective has been added to the laboratory equipment.

EXHIBITS AND LECTURES.

Exhibits.—At the annual meeting of the Connecticut Pomological Society at Hartford in February, and at the fruit exhibit of the same society at Rockville in September, injurious and beneficial species of insects were shown, as well as various insecticides, photographs of spraying operations, mosquito

breeding places, etc. At Rockville a jar of mosquito larvae or wrigglers attracted considerable attention. During the summer similar jars were placed in three stores on Chapel street, New Haven, and in one Hartford store, where they could be seen from the street. Each jar was fitted with an explanatory label and many persons stopped daily to watch the contents of these jars.

Lectures.—Eighteen lectures have been given at farmers' institutes, grange meetings and village improvement societies by the State Entomologist during the season. Three of these lectures have been illustrated with lantern slides.

CORRESPONDENCE.

The work of the office has included the writing of 867 letters. Sixty packages, including mosquito maps, have been sent out by mail and express. One hundred and fifty circular letters have also been mailed.

NURSERY INSPECTION.

During the season 34 nurseries have been inspected. The San José scale is found in most of these; not only in those growing fruit trees but also where there is ornamental stock of kinds liable to be infested. The entomologist requires the owner to destroy all this infested stock before issuing certificate. Most nurserymen are ready to do this, though sometimes under protest. Where a large area of fruit stock or ornamental stock liable to be infested grows near infested trees, or if portions of the stock in the large areas are found infested, the owners are usually required to fumigate with hydrocyanic acid gas the remaining stock before selling it.

All of the large nurseries handling fruit stock and some of the small nurseries which handle only ornamental stock are now fitted with fumigating houses and make a practice of fumigating certain kinds of trees and shrubs when dug for shipment. The form of certificate granted is the same as last year (see Third Report for 1903, page 206).

The accompanying list gives the names of firms receiving certificates during the season:

LIST OF NURSERY FIRMS RECEIVING CERTIFICATES IN 1904.

Name of Firm.	Location.	Inspection Finished.	Certificate Number.
Allen, Chas. I.	Terryville	Oct. 29,	160
Atwater, C. W.	Collinsville	Oct. 10,	148
Barnes Bros. Nursery Co.	Yalesville	Oct. 14,	152
Beers, S. Perry	Greenfield Hill	Nov. 7,	168
Bowditch, J. H.	Pomfret Center	Oct. 11,	149
Bridgeport Nursery	Bridgeport	Oct. 20,	156
Burr & Co., C. R.	Manchester	Sept. 23,	142
Comstock & Lyon	Norwalk	Oct. 13,	150
Conine, F. E.	Stratford	Oct. 14,	151
Conn. Agricultural College	Storrs	Nov. 2,	164
Conn. Valley Orchard Co.	Berlin & Deep River	Nov. 21,	173
Conway, W. B.	New Haven	Nov. 12,	170
Dehn & Bertolf	Greenwich	Nov. 4,	167
East Rock Park Nursery	New Haven	Nov. 1,	163
Elizabeth Park Nursery	Hartford	Oct. 17,	153
Elm City Nursery Co.	New Haven	Sept. 20,	140
Gardner's Nurseries	Cromwell	Nov. 3,	165
Gurney & Co., H. H.	New Canaan	Oct. 5,	145
Hale, J. H.	So. Glastonbury	Oct. 21,	157
Holcomb, Irving	Granby	Oct. 7,	146
Hoyt's Sons Co., Stephen	New Canaan	Oct. 5,	144
Hunt & Co., W. W.	Hartford	Oct. 19,	155
Keney Park Nursery	Hartford	Oct. 24,	158
Kirk, Hugh	Hartford	Sept. 30,	143
Longden, C. E.	North Haven	Nov. 3,	166
Norton, A. F.	New Britain	Oct. 29,	161
Pierson, A. N.	Cromwell	Sept. 22,	141
Platt Co., The Frank S.	New Haven	Nov. 16,	171
Purinton, C. O.	Hartford	Oct. 31,	162
Ryther, O. E.	Norwich	Nov. 10,	169
Vidbourne & Co., J.	Hartford	Oct. 8,	147
Wallace, W. E.	Hartford	Oct. 19,	154
Woodruff, C. V.	Orange	Oct. 28,	159
Woodruff & Sons, S. D.	Orange	Nov. 19,	172

EXAMINATION OF ORCHARDS, GARDENS AND GREENHOUSES.

In addition to the work of inspecting nurseries, the State Entomologist and his assistant have made fifty-four examinations of orchards, gardens and greenhouses to see if pests were present or to advise treatment. Most of these were made at the request of the owner or some other interested party, though the

State Entomologist has made a number of inspections when not requested to do so.

COMPULSORY DESTRUCTION AND TREATMENT OF INFESTED TREES.

In one case it has been necessary for the State Entomologist to make use of the authority given him by Section 4387 of the Statutes regarding the destruction and treatment of infested trees where they had been neglected by orchardists and had become a menace to adjoining owners. The situation was a peculiar one. An orchard of peach, plum and apple trees owned by one man was operated by another under a lease for a period of several years. After the bargain was made the trees were found to be infested with San José scale. While it seemed the duty of the operator to care for the trees according to his agreement, he claimed that the scale was a factor wholly outside of the agreement, and therefore did nothing. Most of the trees were ruined, but were propagating the scale to the great detriment of a nearby orchard. After consulting legal authority, the State Entomologist served notices on both owner and operator to destroy these worthless trees and spray the few remaining trees that were deemed worth saving. The orders were finally obeyed.

CHIEF LINES OF RESEARCH.

San José Scale Experiments.—Spraying experiments to control the San José scale have occupied the attention of the working force of the department. Over 4,000 trees in six different localities were sprayed in the experiments. Spraying mixtures made after fifteen different formulas were used. An account of the experiments will be found elsewhere in this report. Advice was given to many orchardists who practiced spraying.

Mosquito Investigations.—Mosquitoes were collected in both the adult and larval stages and the entire salt marsh area of the state examined for breeding places, which were marked on maps of the region. A detailed report of each town was prepared and sent to the health officer of that town, accompanied by a map showing the location of the breeding areas.

So far about twenty species of mosquitoes have been found in Connecticut, but the number is sure to be increased upon further investigation. The inland region has not yet been systematically examined. An account of the work accomplished will be found in the last half of this report.

Insect Fauna of Connecticut.—Especial attention has been given to collecting and rearing specimens of Connecticut insects for the collection. There is probably not a collection in existence which fairly and adequately represents the insect fauna of our state, though certain orders and families are well represented in several collections. Most of our collecting, however, has been done along the coast and chiefly near New Haven. The northern part of the state and especially the high altitudes should be visited, and collecting trips will probably be made to these localities during the coming season.

Tobacco Insects.—Observations on insects attacking tobacco in Connecticut have been continued, though very few species were found during 1904. Cutworms were about the only tobacco insects that were really abundant during the season.

General Observations on Injurious Insects.—Notes and observations have been made on a large number of fruit, garden, field and shade-tree insects causing injury to plants, crops and trees.

INSECTS SENT FOR IDENTIFICATION.

Each year specimens of insects are received from farmers, fruit-growers, florists and others for identification. This is very necessary work, though sometimes considerable study is required to identify rare or introduced species. But it is useful work and our common pests, of course, can be easily identified. Insects sent by mail should be enclosed in a strong box which will not be crushed in the mail and several specimens with food plants should be sent when possible. During 1904, the State Entomologist has received for identification 140 samples of insects, which are given in the following list:

INSECTS RECEIVED FOR IDENTIFICATION.

DATE.	NAME.	HOST.	LOCALITY.	REMARKS.
1904				
Jan. 2	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple	Gales Ferry	Twigs moderately infested.
"	"	Japan Plum	Shelton	Tree badly infested.
" 19	Hemispherical Scale, <i>Saissetia hemisphaerica</i> Targ.-Tozz.	Fern	Terryville	An adult and several young on fronds.
" 28	San José Scale <i>Aspidiotus perniciosus</i> Comst.	Pear	Hanover	Twigs moderately infested.
Feb. 17	Pear Psylla, <i>Psylla pyricola</i> Först.	"	Cheshire	Twigs covered with sooty mold in which were cast skins of nymphs.
" 23	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple	East Hartford	Twigs thoroughly covered.
" 27	"	Peach	Hartford	A few specimens around buds.
" 29	"	Apple	Thompson	One twig thoroughly infested.
"	Mite, <i>Bryobia pratensis</i> Gar.	White-podded	"	Eggs on same twigs as preceding.
"	Bean Weevil, <i>Bruchus obtectus</i> Say.	Adzuki	"	
Mar. 10	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple, Pear	New Haven	In jar of seeds.
" 14	"	Peach	Southington	A few specimens on twigs.
" 18	"	Peach, Plum	Cannon Station	Small piece of bark thoroughly coated.
" 22	Hickory Borer, <i>Cyllene pictus</i> Dru.	Japan Plum	Vernon	Pieces of bark coated with scales.
"	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	"	Norwich	Found in house.
"	Tent Caterpillar, <i>Malacosoma (Clistocampa) americana</i> Fabr.	"	Windsorville	Twigs well infested.
"	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple	Litchfield	Egg shells of last year.
" 24	"	Apple, Pear, Currant	"	
" 25	"	Apple	Highwood	Twigs completely encrusted.
"	"	Japan Plum	Hartford	Mortality percentage determined.
" 27	"	"	Cromwell	Mortality percentage determined. All were dead—had been fumigated.
" 31	"	Currant	New Haven	Twig dead. Thoroughly infested.
"	"	"	Hartford	
April 1	<i>Megilla fuscicornis</i> Muls.	"	"	Thought to be feeding on San José scale.
" 18	Scurfy Scale, <i>Chionaspis furfuraria</i> Fitch.	Apple	Glastonbury	A few specimens on twigs.
"	Pear Psylla, <i>Psylla pyricola</i> Först.	Pear	Wolcott	Dead skins and black fungus on twigs.
" 21	Apple Aphid, probably <i>Aphis pomi</i> DeG.	Apple	Warehouse Point	Eggs around the buds.

INSECTS RECEIVED FOR IDENTIFICATION—Continued.

DATE.	NAME.	HOST.	LOCALITY.	REMARKS.
1904				
April 27	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple	Meriden	Bark completely covered.
" 29	" " "	Peach	Lebanon	Twigs thoroughly coated.
May 4	Borer, <i>Xylborus dispar</i> Fabr.	Grape	New Milford	Found boring in the stems, causing them to bleed.
"	Hickory Borer, <i>Cyrtene pictus</i> Dru.	Hickory	New Haven	Found crawling around house and cellar where hickory wood was stored.
"	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	Apple	Watertown	Twig well covered: egg stage.
"	Tulip Scale, <i>Eulecanium tulipiferae</i> Cook	Tulip Tree	Suffield	A few old shells on twigs.
" 10	Mite, probably <i>Bryobia pratensis</i> Gar.		Thomaston	Eggs, web and cast skins on a piece of coal.
"	Hemispherical Scale, <i>Sasaelia hemisphaerica</i> Targ.-Tozz.	Myrta	New Haven	A few specimens on leaves.
" 11	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	Lilac	New Haven	Dead twig covered with old shells.
"	Thrips	Chrysanthemum	Westville	Injuring leaves of cuttings.
" 21	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	<i>Akebia quinata</i>	Stratford	Vine killed to the ground. Thoroughly covered.
"	" " "	Pear	Meriden	Twig well covered.
" 26	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	?	New Haven	Living eggs under the shells.
June 2	Maple Leaf-spot Gall, <i>Sciara ocellaris</i> O. S.	Red Maple	Columbia	A large number on a single leaf.
" 6	Plum Curculio, <i>Conotrachelus nenuphar</i> Hbst.	Apple	Meriden	Young apples infested. Eggs and crescent marks.
"	Codling Moth, <i>Carpocapsa pomonella</i> Linn.	"	"	In same fruit as preceding.
" 7	" " "	Peach	Avon	Male scales abundant on bark.
" 9	Spruce Gall Louse, <i>Chermaphis abietis</i> Linn.	Norway Spruce.	Pomfret Center	Galls on new growth of hedge.
"	" " " Scale, <i>Eulecanium sp.</i>	Japan Plum	Bristol	Twig well covered; white eggs under shells.
" 10	Woolly Aphis, probably <i>Chermaphis laricifoliae</i> Fitch.	Larch	New Haven	Infesting leaves.

INSECTS RECEIVED FOR IDENTIFICATION—Continued.

DATE.	NAME.	Host.	LOCALITY.	REMARKS.
1904				
June 10	Rose Leaf-hopper, <i>Typhlocyba rose</i> Linn.	Rose	Yalesville	On under sides of leaves.
" 11	Cucumber Flea-beetle, <i>Epitrix cucumeris</i> Harr.	Tomato	North Windham	Eating small holes in leaves.
" 14	Zebra Caterpillar <i>Mamestra picta</i> Harr.	Black Raspberry, Peas	Bridgeport	Half grown larvæ devouring leaves.
"	Rose Leaf-hopper, <i>Typhlocyba rose</i> Linn.	Rose	New Haven	On leaves.
" 15	Rose Aphid <i>Nectarophora rose</i> Linn.	Rose	New Haven	
"	Stalk Borer <i>Papaipema nitela</i> Guen.	Corn	Springdale	Larva said to be causing much injury to corn.
"	Pear Psylla, <i>Psylla pyricola</i> Först.	Pear	Hartford	A few specimens on twigs.
"	Spittle insect, Cercopid.	Rose	New Haven	Green caterpillar feeding on bud.
" 16	Round-Headed Apple Borer, <i>Saperda candida</i> Fabr.	Grass	So. Wethersfield	Common on grass. Immature.
" 20	Firefly, <i>Photuris pennsylvanica</i> DeG.	Quince	New Haven	Fresh adult specimen: just emerged.
"	— <i>Sphinx luscitiosa</i> Clem.	—	"	Found resting in grass.
"	— <i>Estigmene acrea</i> Dru.	—	"	"
"	Black Long-Sting, <i>Thalassia atrata</i> Fabr.	—	So. Canterbury	Adult female resting on plum tree.
"	Woolly Elm Aphid, <i>Schiononeura americana</i> Riley	Elm	New Haven	Injuring elm trees on College street.
" 21	Hickory Stem Gall Louise, <i>Phylloxera caryacaulis</i> Fitch	Hickory	Norwalk	Galls on leaf stems. <i>Phylloxera</i> in galls.
" 22	San José Scale, <i>Aspidiotis perniciosus</i> Comst.	Apple, Japan Plum	Stamford	Plum and one apple twig coated with living scales.
"	Scurfy Scale, <i>Chionaspis furfura</i> Fitch	Apple	"	Young scales established on twig.
" 24	Apricot Scale, <i>Eulecanium armeniaticum</i> Craw.	Honey Locust	South Norwalk	Twigs thoroughly covered with brown shells filled with eggs.
"	?	Currant	Stamford	Berries had been infested. No insect found in them.
" 25	Stalk Borer, <i>Papaipema nitela</i> Guen.	Pea	Westville	Two larvæ boring in the pods.
"	Grape Gall, <i>Lasiophora vitis</i> O. S.	Grape	Wallingford	Fleshy swellings on shoots of grapevine. Adults have emerged.

INSECTS RECEIVED FOR IDENTIFICATION—Continued.

INSECTS SENT FOR IDENTIFICATION.

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DATE.	NAME.	HOST.	LOCALITY.	REMARKS.
1904				
June 30	Oriental Cockroach, <i>Blatta orientalis</i> Linn.		So. Canterbury	Found in dirty milk cans.
	Black Carpet Beetle, <i>Attagenus piceus</i> Oliv.		"	In dwelling house.
	Lace Wing, <i>Chrysopa</i> sp.		Chapinville.	A number of stalked eggs on plum twig.
	Fly, <i>Elachiptera longula</i> Loew.		New Haven	Small maggots and pupæ in leaves and stems.
July 6	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Hawthorn	Bridgeport.	Small woolly aphids at base of leaf stems.
	Larva of beetle	"	"	On same twigs as preceding.
"	Scurfy Scale, <i>Chionaspis furfura</i> Fitch	Man	New York City	Said to have been voided by a person.
	Oyster Shell Scale <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	Apple	Shelton	Males and females, partially grown.
"	Curiant Aphid, <i>Myzus ribis</i> Linn.	Lilac	"	Partially grown young and old shells on bark.
"	Poplar Stem Gall, <i>Pemphigus populicaulis</i> Fitch.	Curiant	"	Leaf well infested.
11	Rudbeckia Aphid, <i>Nectarophora rudbeckiae</i> Fitch	Carolina Poplar.	Hartford	Galls on leaf petioles.
		Rudbeckia		
"	Tarnished Plant Bug, <i>Lygus pratensis</i> Linn.	Golden Glow	Whitneyville.	Stem covered with red lice.
12	Lesser prionus, <i>Orthosoma brunneum</i> Först	Tobacco.	Poquonock	Said to cause portions to drop from leaves.
"	Red Spider, <i>Tetranychus telarius</i> Linn.	Decayed wood	New Haven	Received as a pupa and reared.
"	Mites	Phlox	West Haven	Injuring leaves.
15	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Larkspur		Small white mites injuring flowers.
16	Grape Gall, <i>Lasioptera vitis</i> O. S.	Apple, Plum	Hartford	Dead twigs moderately infested.
"	<i>Procus</i> sp.	Grape	Stratford	Galls on new shoots and leaves.
25	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	"	"	Crawling on twigs.
"	Lady-beetle, <i>Brachycantha urtica</i> Fabr.	Lilac.	Branford	Old shells and young scales on twigs.
26	—	Dahlia	Norwalk	Found on injured dahlia. Supposed to have caused the injury.
"	—			Buds fell off.
"	<i>Harpalus caliginosus</i> Fabr.		Hartford	Sent for identification.
"	<i>Phoksora catullus</i> Fabr.	"	"	"
"	<i>Xylophasia arctica</i> Boidv.	"	"	"

INSECTS RECEIVED FOR IDENTIFICATION—Continued.

DATE.	NAME.	HOST.	LOCALITY.	REMARKS.
1904				
July 26	Lady-beetle, <i>Spogostylum simsoni</i> Fabr.		Hartford	Sent for identification.
"	Carpenter Ant, <i>Camponotus pennsylvanicus</i> DeGeer.		"	"
"	" <i>Pteronarcys nobilis</i> Hagen.		"	"
27	Codling Moth, <i>Carpocapsa pomonella</i> Linn.	Apple	Shelton	A single larva found in infested apples.
"	Aphis, <i>Aphis rumicis</i> Linn.?	Lima Beans.	Madison	Plant completely covered with black lice.
28	Grape Gall, <i>Lasiophora vitis</i> O. S.	Grape	New Haven	Galls on new shoots.
"	Red Spider, <i>Tetranychus telarius</i> Linn.	Apple	"	On leaves of new growth.
"	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Pear	Meriden	Dead twigs well covered.
"	Tarnished Plant Bug, <i>Lygus pratensis</i> Linn.	Dahlia	Norwalk	Injuring buds causing them to drop.
"	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	Ash	New Haven	Stem completely covered.
30	American Silk Worm Moth, <i>Tetia polyphemus</i> Cramer.		New " "	Adult.
Aug. 1	Sawfly	Willow	Fairfield	Larvæ eating leaves.
"	Galls	"	"	Hymenopterous galls on leaves.
2	Mossy Rose Gall, <i>Rhodites rosae</i> Linn.	Shad Bush	West Cornwall	Galls on leaves.
"	Tomato Worm, <i>Phlegelthontus</i>	Rose	"	Spherical mossy galls on twigs.
4	"	Potato	New Haven	Larva feeding upon potato plant.
8	"	Grape	Sound View	Galls on leaves.
9	Sawfly,	Pansy	Norwalk	Larvæ eating leaves.
15	" <i>Phenacoccus acericola</i> King	Maple	South Norwalk	White cottony cases on under side of leaves.
16	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Apple	West Haven	Twigs and leaves well infested.
18	Dog Day Harvest Fly, <i>Cicada canicularis</i> Hart.		New Haven	Pupa skin, with adult just emerged.
24	Tulip Scale, <i>Eulecanium tulipifera</i> Cook	Tulip Tree	Wilton	Adult females and eggs.
"	Saddle Back Caterpillar, <i>Sibine stimulia</i> Clem.	Rose	Kensington	Larvæ devouring leaves.
25	Scurfy Scale, <i>Chionaspis furfura</i> Fitch	Plum	East Norwalk	Males abundant.
"	San José Scale, <i>Aspidiotus perniciosus</i> Comst.	"	"	On bark with preceding.
29	Sawfly,	Pine	Governors Island	Single larva.
31	Fall Web Worm, <i>Hyphantria cunea</i> Dr.	Apple	New Haven	Branch with web and young larvæ.

INSECTS RECEIVED FOR IDENTIFICATION—Continued.

DATE.	NAME.	HOST.	LOCALITY.	REMARKS.
1904				
Aug. 31	Milkweed Butterfly, <i>Anosia plexippus</i> Linn.	-----	New Haven	Chrysalis on twig.
Sept.	8 Cecropia, <i>Samia cecropia</i> Linn.	-----	"	Larva found crawling on the ground.
"	9 Milkweed Butterfly, <i>Anosia plexippus</i> Linn.	-----	So. Canterbury	-----
"	Fall Web Worm, <i>Hyphantria cunea</i> Dru.	-----	"	Nests reported numerous.
"	Uhler's Plant Bug, <i>Halticus uhleri</i> Giard	-----	Southport	Causing great injury to smilax under glass.
"	Borer, <i>Saperda</i> ?	European White Birch	New Haven	Larva boring in trunk of small tree.
"	11 Cecropia, <i>Samia cecropia</i> Linn.	Witch Hazel	"	Larva.
"	Bumble Flower Beetle, <i>Euphoria inda</i> Linn.	-----	"	Adult found in dwelling house.
"	12 Io Caterpillars, <i>Automeris</i> 10 Fabr.	-----	Mystic	Larvæ probably parasitized.
"	Oyster Shell Scale, <i>Lepidosaphes ulmi</i> Linn. (<i>Mytilaspis pomorum</i> Bouché)	Lilac	New Haven	-----
"	14 ——— <i>Psacus</i> sp. ?	Apple	Noroton	Single adult badly crushed.
"	21 Scurfy Scale, <i>Chionaspis furfura</i> Fitch	-----	Middletown	Twig completely covered with males.
"	22 Chain Dotted Geometer, <i>Cingilia catenaria</i> Cram.	-----	New Haven	Tree about dead.
"	26 Hag Moth, <i>Phobetron pithecium</i> S. & A.	Maple	-----	Adult specimen, emerged from cocoon on purple aster.
"	27 Blister Beetle, <i>Meloe angusticollis</i> Say	-----	"	Young larva with few lateral projections.
Oct.	6 Euonymus Scale, <i>Chionaspis euonymi</i> Comst. ?	<i>Euonymus</i>	West Stafford	Pair of adults.
"	12 ——— <i>Typophorus canellus</i> Fabr.	Strawberry	Phila., Pa.	Leaf completely covered. Mostly males.
"	10 ——— <i>Crochilus villosus</i> Grav.	-----	So. Manchester	Leaves eaten by beetles.
Nov.	10 San José Scale, <i>Aspidiotus perniciosus</i> Comst.	European Beech	Hartford	Found in house.
"	17 Borer, <i>Podoresia syringae</i> Harris	<i>Ligustrum ibota</i>	New Haven	Trunk well infested.
Dec.	15 Cave Cricket, <i>Ceuthophilus</i> sp. ?	-----	"	Larva boring in stem near the ground.
"	21 Mites, probably <i>Bryobia pratensis</i> Gar.	Camellia	"	Found in cellar.
"	29 San José Scale, <i>Aspidiotus perniciosus</i> Comst.	Japan Plum	Warehouse Point	Many globular red eggs on leaves in greenhouse.
"			Groton	Twigs quite thoroughly coated.

ENTOMOLOGICAL FEATURES OF 1904.

Perhaps the most distinctive feature of the season that would tend to influence insect life was the very severe winter. A prolonged period of low temperature is generally supposed to prove less disastrous to most forms of insect life than sudden and wide variations in temperature. But a larger proportion of the over-wintering San José scales were killed than has previously been observed in Connecticut. Ordinarily about 25 per cent. are winter-killed, but in examining twigs last spring in connection with our spraying experiments described on page 221 of this report we found at least 50 per cent. killed, and in some cases the mortality was even greater. Of course the survivors multiplied rapidly the latter part of the season, covering the trees in many cases. Yet the pest was considerably checked in its spread by the winter.

The Colorado potato beetle, *Doryphora decemlineata* Say, which was comparatively scarce during 1903, was not abundant early in 1904, but late in the season it was very common. After the potato fields had ripened, adult beetles could be found everywhere, devouring tomato, tobacco and other solanaceous plants. An abundance of these beetles may be expected next season.

Cutworms were abundant and caused much damage in the fields and gardens in early summer. Some of these were collected, but the adults have not yet been obtained. The use of poisoned bait to kill cutworms has not yet become general in Connecticut, and considerable injury results each year. A sweetened mash made of wheat middlings and containing a little Paris green or some other arsenical poison, scattered about over the field a week or ten days before the plants are set or before the seedlings appear, will do much to prevent injury by poisoning the cutworms.

The apple aphid, *Aphis pomi* De Geer, was scarce during the season and therefore caused little damage.

The codling moth, *Carpocapsa pomonella* Linn., was fully as common as usual, and unsprayed apples were greatly injured.

NOTES.

Galls on Honey Locust.—On June 15th some young trees of honey locust, *Gleditschia tricanthos*, growing upon the station grounds presented a peculiar appearance. Each leaflet of the

compound leaves was rolled up, swollen and much distorted. Inside of each was found one or more maggots. Material was gathered, and as some of the maggots were full grown they soon pupated, and the adults emerged in a few days. This gall-forming insect proved to be *Cecidomyia gleditchiae* O. S., a species closely allied to the Hessian fly. There are several species of *Cecidomyia* which form galls upon plants.

During the latter part of June the writer observed large honey locust trees at Middlefield which had been attacked in the same manner and presumably by the same insect.

The leaves only are affected, and their function not seriously impaired, so that little real damage is done to the tree, but the galls render it more or less unsightly. There is probably no remedy. The galls are shown on plate II, b.

Pear Psylla Held in Check by Lime and Sulphur Spray.—The pear trees at the station have been injured somewhat each season for several years by the pear psylla, *Psylla pyricola* Först. During the past summer, after spraying these trees with lime and sulphur mixtures to kill San José scale, it was noted that the pear psylla was scarce, though the insect was several times observed in other localities where it caused more or less injury.

Dr. E. P. Felt, State Entomologist of New York, informs us that he has found the insect checked by the lime and sulphur spray, and A. E. Plant & Son of Branford have a pear orchard which has been infested with psylla for several years. This orchard has recently become infested with San José scale, and was thoroughly sprayed last April with the boiled lime and sulphur mixture. Mr. A. B. Plant states that it was very difficult to find a psylla in the orchard during the summer. The pear psylla has been a difficult pest to control, and as it passes the winter as an adult it is quite probable that the spraying in early spring may destroy the adults before they lay their eggs. There will be an added satisfaction in spraying to control the scale if we can expect to also check some other serious pests.

Fall Web Worm Double-Brooded in Connecticut.—This insect has been rather abundant for many years, but was especially so in this state in 1901, and less so each year since. The first nest of the season was found in Westville, June 23d on a pear tree. This was brought to the laboratory, and the caterpillars, fed upon pear leaves, grew rapidly, and by July 29th nearly all had

pupated. On August 1st two adults had appeared, and on the morning of the 5th, thirty adults representing both sexes had emerged. All of these had immaculate wings. Two masses of eggs had also been laid on the side of the breeding cage. These were bright green in color instead of golden yellow, which is the usual color, according to most writers. The eggs had hatched on August 15th, and the larvae were reared until nearly full-grown, but as we were busy inspecting nurseries, and did not supply them with food, all of them died. These observations indicate that the species is partially double-brooded in this latitude, and though it has long been known to be double-brooded south of New York City, only one brood occurs in Massachusetts. These early nests were very rare, and most of the injury to trees came during August and September, so that probably there is but one complete brood as a rule in Connecticut.

Onion Maggot, Phorbia ceparum Bouché.—This insect has been unusually abundant the past season, causing much injury to the onion crop. At Greens Farms and Southport large fields were attacked and in some cases one-fourth to one-third of the plants killed. The highest and driest portion of the field seemed to be preferred by the pest, for in such places the most serious damage occurred. Around New Haven, observations indicate that the crop was injured in much the same manner and degree. No satisfactory remedy seems to have been discovered by the growers. Some recommend a sprinkling of salt along the rows; others declare that it does no good. Covering the surface of the ground around the plants with sand treated with kerosene appears to be a preventive. Perhaps the kerosene could be sprayed upon the surface of the soil with equally good results.

An Enemy of Japanese Iris.—On June 30th some plants were brought to the laboratory from a nearby nursery. At the base of the leaves a number of maggots were at work, and the plants looked sickly. The leaves were even beginning to decay at the point of injury. The maggots were yellow and about 3 mm. in length. Some of them soon pupated, and the puparium measured 3 mm. in length and about .5 mm. in width in the middle, tapering towards both ends. The insect proved to be *Elachiptera longula* Loew.

Books Injured by Cockroaches.—While employed at the station, Mr. H. L. Viereck roomed in a new six-story building having a restaurant on the top floor. This restaurant was overrun with Croton bugs or cockroaches, *Blattella germanica* Linn. A man who was employed to destroy them visited the place at intervals and distributed roach powder on the top floor of the building, which drove the roaches down the steam pipes into other parts of the building. A number of Mr. Viereck's book bindings were ruined by the roaches, and one of these is shown in plate III, b.

These insects are especially fond of the paste and sizing used in book-binding. Usually they feed upon waste food materials both animal and vegetable. Crumbs and cereals are often devoured, and occasionally leather and cloth are injured by them.

Pyrethrum powder, sulphur and borax are used as repellants to drive away roaches; it is difficult to make them eat bait poisoned with arsenic, as they seem able to detect the poison even when present in very small quantities. Flour paste containing phosphorus is known to be a fairly effective material for destroying these insects, and it also acts as a repellant.

Where a house or room can be closed tightly, fumigating with hydrocyanic acid gas is doubtless the most satisfactory remedy, as it destroys all forms of animal life therein.

Caterpillars Devouring Geranium Leaves.—During a visit to a greenhouse in January it was observed that green caterpillars were eating the foliage of geranium cuttings that were put out on the cutting bench to be rooted. The gardener stated that considerable injury resulted from the attacks of these caterpillars, and that it had been found necessary to look over the cuttings every day to destroy the larvae. Specimens were taken to the laboratory and fed on geranium leaves. They soon reached their larval maturity and spun white cocoons among the leaves in which they pupated. On February 1st the adults emerged. The insect proved to be *Autographa biloba* Steph.

Severe Injury to Strawberries by the Strawberry Root Borer.—During October specimens of beetles were received from South Manchester, where they were reported to be causing considerable injury to strawberry fields, having just destroyed two acres of plants. The beetles were feeding upon the leaves, and

Paris green had been used without apparent success. The beetle was recognized as the strawberry root borer *Typophorus canellus* Fabr., formerly placed in the genus *Paria*. The larvae of this beetle are borers in the roots of the plants, and the adults appear in late summer and fall and feed upon the leaves. Stronger mixtures of Paris green or arsenate of lead were advised. The damage is usually greater on old fields, and there is very little about this insect in the literature of economic entomology.

The Apple or Currant Leaf Hopper, Empoasca mali LeB.—Small light-green leaf hoppers are often seen on the under sides of the leaves of young apple trees, and occasionally considerable injury is done by them. They feed by sucking out

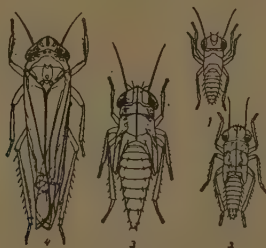


FIG. 7.—The apple leaf hopper, *Empoasca mali* LeB., in its different stages. (After Washburn, 9th Report State Entomologist of Minnesota.)

the juices of the plant, and infested leaves show white spots or patches where attacked. Like other leaf hoppers, this insect does not pass through the four distinct stages common to most kinds of insects, but by a more gradual development and increase in size it passes into the adult stage. The apple leaf hopper is sometimes a serious pest in nurseries, and combative measures must be employed. In Missouri, and the past season in Minnesota, this insect has been so injurious to nursery trees that a special spraying apparatus was devised for treating several rows at once, kerosene emulsion being used. This leaf hopper also attacks currants, and plate III, a, shows the appearance of an injured leaf; beside it is shown a healthy leaf for comparison. The grape-vine leaf hopper, *Typhlocyba comes* Say., is closely related to *E. mali*, which also attacks the grape, and is combatted in the vineyards of New York State

by catching the adults upon sticky shields in early June. The young hoppers are readily killed by a spray of 'whale-oil soap (one pound to ten gallons of water) or with kerosene emulsion. The adults may be killed by first knocking them to the ground with a spray of whale-oil soap and then quickly covering them with a spray of 25 per cent. kerosene emulsion, which would be too strong for the foliage of the vines.* See Fig. 7.

Sawfly on Ash.—On May 31st, white and green ash trees at the station were covered with sawfly larvae of different sizes. The smallest were about three-eighths of an inch long,



FIG. 8.—The garden flea hopper, *Halticus uhleri* Giard: a. brachypterous female: b. full-winged female: c. male: d. head of male, side view. All much enlarged. (After Chittenden, Bulletin 33, Bureau of Entomology, U. S. Department of Agriculture.)

while the largest ones were nearly twice this length. The larva is pale greenish white on the back, with a darker green median stripe. Head and legs are black. The first two thoracic segments are yellowish green, and this color extends along each side of the body, and on the pro-legs. A few individuals were marked somewhat differently, having a light-green dorsal stripe on either side of the dark stripe. These larvae had light heads and legs. The adults have not been obtained, but some of the larvae entered the ground June 6th to pupate. The larvae are shown on plate III, c.

Garden Flea Hopper Injuring Smilax.—During September some specimens were received from Southport with the statement that much injury to smilax growing under glass was being done by this insect. The insect in question was *Halticus*

* M. V. Slingerland, Bull. 215, Cornell Experiment Station, page 102.

uhleri Giard, a small black bug which has caused much injury to various plants in various parts of the country. The plants attacked are beans, beets, red clover, cow pea, potato, chrysanthemum, morning-glory, egg-plant, cabbage and pumpkin. The accompanying figure shows the appearance of this insect in its different stages. The wingless form resembles some of the flea beetles. Tobacco fumes were employed in the smilax house, but did not kill the flea hoppers; hydrocyanic acid gas was next tried with greater success. Spraying with kerosene emulsion has been recommended as a remedy, and doubtless common soap and water would serve the purpose if strong enough and applied as a spray.

The Tarnished Plant Bug, Lygus pratensis Linn.—Specimens



FIG. 9.—The tarnished plant bug, *Lygus pratensis* Linn: adult at left: last stage of nymph at right. Enlarged about four times. (After Chittenden, Bulletin 43, Bureau of Entomology, U. S. Department of Agriculture.)

of this insect were received in July from Norwalk, where they were injuring dahlias by sucking the juices from the buds and their stems, causing them to drop before opening. The same species was thought to be injuring tobacco at Poquonock in June. Portions of the leaves turned brown and dropped out, giving the leaves a ragged appearance. These bugs were found upon the plants, but it is not certain that they were responsible for the injury, though it is quite probable. The tarnished plant bug is known to attack a very large number of different plants, including fruit and vegetable crops, nursery trees, and even weeds. It is one of the commonest of those sucking insects which are known as the true bugs, and may be found on plants from early in spring until the cold weather of autumn drives it into winter quarters, where it lives as an

adult. The adult insect is about one-fifth of an inch long, of a greyish brown color varying greatly from a light brown to nearly black. There are obscure markings of black, red and yellow, also variable. The immature bugs are perhaps oftenest seen upon the plants, and are yellowish green in color, with undeveloped wings. The adults are very active, and when disturbed they dodge about or fly away from the plant, and are difficult to capture. The injury which they do consists in sucking the juices from the buds and new growths, often causing the same to wither and turn black. As the insect attacks so many different kinds of plants, remedial treatment is difficult to apply successfully. Kerosene emulsion is one of the best sprays, but must be applied thoroughly and frequently to hold the insect in check. Sometimes it is necessary to spray the other plants around those which we wish to protect. Sweeping over the garden plants and weeds with an insect net will result in capturing a great many specimens in a short time if they are abundant, and this is one of the best methods of holding the species in check in the house garden. The insect is shown in figure 9.

APPLES SERIOUSLY INJURED BY PLUM CURCULIO.

For several seasons it has been apparent that much injury to the apple crop resulted from the attack of the plum curculio *Conotrachelus nenuphar* Hbst., yet it was thought that spraying with poisons would prevent serious damage. During 1904, the trouble seemed to be much worse than at any time during the past ten years, and many of the young apples showed the characteristic crescent-shaped mark where the eggs are laid. The photograph reproduced on plate II, a, shows this mark and the many scars where the injury has partially healed. Where the fruit does not fall, the injury heals over, but a hard woody streak or vein runs through the flesh of the apple, and the fruit is gnarled and irregular in external appearance. I believe that in former years we have attributed much of this injury to the apple curculio *Anthonomus quadrigibbus* Say., a species that is probably not sufficiently abundant to cause so much injury.

Until recently, however, very little has been known regarding this plum curculio injury to apples, and a bulletin from the Missouri station by Professor J. M. Stedman is therefore

very welcome and timely, and I have drawn upon it freely in what follows.

Professor Stedman states that the adult curculios attack the apples while they are about the size of cherries, which is not far from the middle of May in Missouri. Both sexes puncture the fruit for food, but in addition to this the female makes punctures for the purpose of depositing eggs, each egg being placed in the hole and a crescent cut through the skin of the apple around the egg, so that it may not become injured by the pressure of the rapidly growing fruit. The feeding punctures are more numerous than the egg punctures, and either is liable to be the starting point of the various kinds of fungi and bacteria causing decay. If the fruit does not decay, it becomes knotty, irregular and greatly injured in quality as well as in appearance. While each female is capable of laying from 300 to 400 eggs, few of the eggs hatch in the apple. Professor Stedman examined thousands of apples in Missouri and found eggs in only about half of the egg punctures, even where crescents were made around them. Of the eggs deposited not more than 15 per cent. hatch on the average, and of those which hatch only 24 per cent. reach the full grown larval stage. The larvae seem to nearly always die if the apple remains on the tree, but if it falls when the grub is half grown or smaller, the latter may reach maturity. Only about 2 per cent. of the eggs laid in the apple ever produce insects that reach the adult or beetle stage. The apple, then, furnishes an abundance of food for the beetles, but is not a successful breeding place compared with the plum or the cherry. The eggs are white, and oval in shape. These hatch in about a week, and the larva, a white footless grub, begins to eat its way into the pulp of the apple, going in a zigzag course, but finally reaching the core, and becoming full grown in about three weeks if the apple falls from the tree. It then enters the ground one or two inches below the surface, where it transforms to the pupa stage in a little cell. From fifteen to twenty days later the adult curculio is formed, but it does not emerge for about ten days, when it leaves the soil and seeks its food on the fruit, where it feeds until fall, when it crawls into a sheltered place to pass the winter. The adult is a brown beetle with a long snout or proboscis, and is shown in figure 10. There is but one

brood each year. Apples received from Meriden on June 6th were badly injured on account of feeding and egg punctures, some of which were nearly healed. Apples growing upon the station grounds showed similar injury.

At a meeting of the American Association of Economic Entomologists at Philadelphia in December, 1904, Professor S. A. Forbes of Illinois read a paper on the results of his experiments in spraying with arsenate of lead to prevent injury by this curculio. While the spraying gave a larger quantity of perfect fruit, the minimum amount of injured fruit still remained about 28 per cent., which seems a large proportion.



FIG 10.—The plum curculio, *Conotrachelus nenuphar* Hbst. Adult beetle. About six times natural size.

Professor Forbes explained this by saying that the beetles could not be killed by the poison unless they fed upon the fruit or leaves covered with it; and in doing an amount of eating sufficient to be poisoned they injured 28 per cent. of the fruit.

In Missouri similar results were obtained from spraying, but it was found that a combination of spraying, cultivation and the destruction of fallen fruit was the most satisfactory method of combating the insect. Arsenical poisons applied early, the destruction of windfalls, and shallow cultivation of the soil under the trees from July 15th to August 15th is therefore recommended as a treatment to prevent injury to apples from the attacks of the plum curculio.

SAN JOSÉ SCALE-INSECT EXPERIMENTS IN 1904.*

BY W. E. BRITTON AND B. H. WALDEN.

Bulletin 144 of this station contains an account of the experimental spraying work against the San José scale-insect for 1903. In December of that year tests were made in Bridgeport to

* This was published as Bulletin 146 and distributed in November. It is here reproduced with slight emendations.

determine whether fall or early winter spraying with lime and sulphur could be depended upon to hold the scale in check in Connecticut. About 770 trees, mostly Japan plum, with a few peach and pear trees, were treated. A few trees in New Haven were also sprayed in the fall.

In the spring of 1904, spraying experiments were conducted at New Haven, Westville, Wallingford, Milford and Southington. The boiled mixture did not seem to adhere to the trees as well as last year, doubtless owing to the different climatic conditions. Wherever the lime and sulphur mixtures are used there is a decided tendency for the young scales to set upon the fruit and leaves instead of the twigs that have been covered with the spray mixture. This is doubtless the case where any adhesive mixture is used, and often the fruit is disfigured by the scales when they are not abundant on the twigs.

All of the lime and sulphur mixtures seem to have considerable value as fungicides.

Young scales were first observed crawling on June 25, at New Haven.

The whole number of trees and plants treated in these experiments was approximately as follows:

Bridgeport	772	} December treatment.
New Haven	14	
Westville	150	} Spring treatment.
Wallingford	130	
Milford	481	
Southington	2552	
New Haven	35	
Total	4134	

The effects of the winter on the trees make it impracticable in many cases to express the results of the spring treatment in exact figures, as was done in bulletin 144. In some cases, however, this can be done, and we consider the general results to be of sufficient value for publication, and so present them in the following pages:

EFFECT OF THE WINTER ON THE TREES.

It would be manifestly unfair to give any account of experimental spraying work against the San José scale-insect without mentioning the very unusual effect of the season in causing injury to trees and orchards. The extraordinary winter killed

many peach and plum trees in Connecticut, and thousands were seriously injured. Scale-infested trees, as a rule, were the first to show this injury and thousands of such trees in peach orchards went into the winter in a weakened condition never to leaf out again. But the damage was by no means confined to infested trees. In some places young and vigorous peach trees were frozen and killed to the snow line and had to be cut away, while in many orchards, especially on the lower levels, the fruit buds were entirely destroyed. In some instances trees leafed out, but soon withered and died. Large apple trees in different parts of the state appeared sickly in June and July and some of the branches withered and died. An examination failed to show the presence of any parasitic trouble, and their condition could be ascribed only to winter injury. On the whole, Connecticut orchards suffered a vast amount of damage, from which some of them will not recover in several years, if ever.

At the time of cutting twigs to examine the insects prior to spraying, the best looking infested twigs were selected, but the extent of this winter injury could not then be determined. But in many cases the infested wood was injured or dead and most or all of the scale-insects were dead in consequence, before the spray was applied.

In June, when the twigs were cut for the second examination to show the effect of the treatment, the trees were in leaf and it was easy to distinguish the living from the dead branches. Only living branches, of course, were examined at this time, and in some cases the number of living insects after the treatment exceeded the number found on the injured branches at the first examination.

EFFECT OF THE WINTER ON THE INSECTS.

Ordinarily we find that a portion of San José scale-insects are killed each winter—probably by the climatic conditions. Twenty-five per cent. is about the average mortality, and 75 per cent. of living insects is about the number that we expect to find when we cut twigs for examination in March or April. The past winter proved to be an exception to this rule, the mortality being much greater than usual. Seldom did we find 50 per cent. of the scale-insects alive, even on healthy twigs.

So many of the twigs were injured that much less than 50 per cent. of the whole number of scale-insects actually survived the winter.

MATERIALS USED IN SPRAYING.

Various materials prepared after 15 different formulas were used in these experiments. The formulas are given below, each with a separate number, by which it is designated in the following pages. The details of preparing each are given on pages 240-247.

Boiled Mixtures.

- | | | |
|--|---|--|
| 1.—14 lbs. lime.
14 lbs. sulphur.
40 galls. water. | } | Flowers of sulphur made into a paste and |
| | | slaked with lime. Mixture boiled 30 minutes |
| | | with steam. |
| 2.—14 lbs. lime.
14 lbs. sulphur.
40 galls. water. | } | Light sulphur flour not made into a paste but |
| | | added dry to the slaking lime. Boiled 45 to 60 |
| | | minutes. |
| 3.—20 lbs. lime.
14 lbs. sulphur.
40 galls. water. | } | Light sulphur flour not made into a paste but |
| | | added dry to the slaking lime. Boiled 45 to 60 |
| | | minutes. |

Mixtures not Boiled.

- | | | |
|---|---|---|
| 4.—20 lbs. lime.
20 lbs. potassium sulphide.
40 galls. water. | } | Lime slaked and potassium sulphide |
| | | dissolved separately and then put to- |
| | | gether with the proper quantity of |
| 5.—20 lbs. lime.
20 lbs. sodium sulphide.
40 galls. water. | } | Fused sodium sulphide broken into |
| | | small lumps and added to the slaking |
| | | lime. |
| 6.—20 lbs. lime.
16 lbs. sodium sulphide.
40 galls. water. | } | Fused sodium sulphide broken into |
| | | small lumps and added to the slaking |
| | | lime. |
| 7.—20 lbs. lime.
6 lbs. sulphur.
6 lbs. sodium sulphide.
40 galls. water. | } | Light sulphur flour, sulphide in lumps, |
| | | both added to slaking lime. |
| | | |
| 8.—20 lbs. lime.
11 lbs. sulphur.
11 lbs. sodium sulphide.
40 galls. water. | } | Light sulphur flour, sulphide in lumps, |
| | | both added to slaking lime. |
| | | |
| 9.—14 lbs. lime.
6 lbs. sulphur.
6 lbs. sodium sulphide.
40 galls. water. | } | Flowers of sulphur, sulphide in lumps, |
| | | both added to slaking lime. |
| | | |
| 10.—14 lbs. lime.
11 lbs. sulphur.
11 lbs. sodium sulphide.
40 galls. water. | } | Flowers of sulphur, sulphide in lumps |
| | | both added to slaking lime. |
| | | |
| 11.—20 lbs. lime.
14 lbs. sulphur.
6 lbs. sodium sulphide.
40 galls. water. | } | Flowers of sulphur, sulphide in lumps, |
| | | both added to slaking lime. |
| | | |

- | | | |
|---------------------------|---|---|
| 12.— 8 lbs. caustic soda. | } | Dissolved soda in cold water and applied. |
| 40 galls. water. | | |
| 13.— 7 lbs. caustic soda. | } | Dissolved soda in cold water and applied. |
| 40 galls. water. | | |
| 14.— 14 lbs. lime. | } | Light sulphur flour and caustic soda added to the slaking lime. |
| 14 lbs. sulphur. | | |
| 7 lbs. caustic soda. | | |
| 40 galls. water. | | |
| 15.— 20 lbs. lime. | } | Light sulphur flour and caustic soda added to the slaking lime. |
| 14 lbs. sulphur. | | |
| 5 lbs. caustic soda. | | |
| 40 galls. water. | | |

EARLY WINTER SPRAYING.

On account of the unfavorable weather and the rush of work in late winter and spring, it would frequently be more convenient for orchardists to spray in the fall. Ordinarily in Connecticut the San José scale-insect continues breeding until about December 1. Last fall the young were observed crawling on December 2. We believe that if the spraying can be done as soon as the leaves drop or during November, that a large proportion of the young will be killed, and that they are much more susceptible to the effect of the sprays than after they are partially grown and better protected by their shells or armor. The mature insects die naturally, before spring, and it is only the half or partially grown individuals that carry the species through the winter.

The experiments in fall spraying herein described were made December 10 and later, and though satisfactory it seems reasonable that even better results might follow from a treatment made two weeks earlier in the season.

Experiments at Bridgeport.

At Bridgeport an orchard of about six hundred Japanese plum, one hundred and twenty-five peach, thirty-four pear and ten quince trees was sprayed with the lime and sulphur mixture December 10 and 11. The trees were quite close together and irregular in size. This orchard was sprayed in the spring of 1902 with crude oil and water. While this treatment was quite successful, some scales came through alive, and as the orchard is in a badly infested locality, conditions were favorable for the scale to continue to breed. Since the treatment in 1902, trees which became badly infested were sprayed with kerosene

emulsion, whale oil soap, or other similar mixtures. At the time of the last treatment, the orchard was not badly infested, but scales could be found on nearly every tree.

The lime and sulphur mixture was prepared at a near-by woodyard, where a twenty horse-power upright boiler furnished steam to cook the mixture. A fifty gallon cask was used for boiling the mixture, steam being conveyed through a hose connected to the boiler.

The following formula (No. 1) was used:

14 lbs. fresh finishing lime.
14 lbs. flowers of sulphur.
40 galls. water.

The sulphur was made into a thick smooth paste with water as hot as could be conveniently borne by the hands, which were used to work the lumps out of the paste. The lime was put into a barrel, hot water added, and as soon as it commenced to slake the sulphur paste was poured in, and the whole stirred to prevent the lime from "burning." By the time the lime was slaked we had a smooth mixture which was assuming a darker color, showing that the sulphur was being dissolved. About one-third the required amount of water was then added, the steam turned on and the mixture boiled vigorously for thirty minutes. This was stirred frequently, and the hose moved to different places in the barrel so that the mixture was kept well agitated. The boiled mixture was dipped out and strained into the pump barrel.

The sulphur appeared to be all dissolved, and very little sediment was present, that which accumulated in the strainer being practically all washed through with cold water. After the boiled lime and sulphur mixture was transferred to the pump barrel, cold water was added until the barrel was filled within about four inches of the top. This made practically forty gallons.

The spraying outfit consisted of a barrel pump, mounted on the end of a forty-five gallon barrel. This was placed on a low wagon, and fitted with two lines of one-half inch hose from thirty to forty feet long. To each line of hose was attached an eight-foot bamboo extension with a double Vermorel nozzle.

The trees were coated as thoroughly as possible. On some of the trees that had been sprayed with the soap and oil solu-

tions the mixture did not seem to stick as well, and when the trees dried the coating was of a bluish grey color.

TABLE I.—LATE FALL SPRAYING AT BRIDGEPORT, DEC. 10 AND 11, 1903.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs.				Effect of treatment on trees.
				Winter-killed.	Killed by treatment and winter.	Alive Jan. 2, 1904.	Alive June 22, 1904.	
Pear -----	34	Moderately infested.	Formula No. 1— 14 lbs. lime.	00	93	18	7	No injury.
Peach -----	125	"	14 lbs. sulphur.	00	91	19	9	"
Jap. Plum -	600	"	40 galls. water.	00	84	18	16	"
Wild Plum	3	"	"	00	85	15	---	"
Quince ----	10	"	"	00	---	---	---	---
Average.	772				88	17.5	10.6	

No twigs were cut for the purpose of examining the scales at the time of treatment, but it was assumed that 100 per

cent. were alive at that time, as the insects had been breeding up to a few days previous and there had been no cold weather to cause wholesale destruction of them. Twigs were cut January 2, 1904, and examined, and again on June 22. The figures are given in Table I. on page 227.

Results at Bridgeport.

It has already been stated that the trees were not made very white by the mixture (Formula No. 1). This is partly due to the fact that oil had previously been used on some of the trees, and partly due to the small quantity of lime in the mixture. Nevertheless, the adhesive qualities were good and the mixture could be seen on the trees in some places when the final examination was made on October 20.

On December 10-11, when the spraying was done, the scales were about all alive. On January 2, less than a month after the application, twigs were cut and examined, with the result that an average of 17.5 per cent. of living insects were found. This can fairly be attributed to the effect of the treatment, principally because no severe weather or ice storms had occurred to kill the scale-insects in unusual numbers.

The results of the second examination of twigs on June 22 are somewhat disappointing, as an average of 10.6 per cent. of living insects were found after one of the most severe winters known in recent years. In spite of the rather large percentage of living insects in this test, the writers believe that fall or early winter spraying can and soon will be practiced by the growers. We shall make further tests along this line. The following account of fall spraying at New Haven shows better results in figures than the Bridgeport experiments.

When the final examination was made of the sprayed trees at Bridgeport on October 20, they were found to be in a very satisfactory condition. The trees had made good growth, borne a crop of fruit and few living scale-insects could be found.

Experiments at New Haven.

On December 19 a number of small trees and shrubs in the western part of the city were sprayed with the lime and sodium sulphide mixture (Formula No. 5). The sulphide was broken into lumps not larger than butternuts and was added to the lime after the slaking process was well started with hot water.

After slaking the lime the whole was allowed to stand for a few minutes, utilizing the heat to help dissolve the lumps of sodium

TABLE II.—LATE FALL SPRAYING AT NEW HAVEN, DECEMBER 19, 1903.

Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Out of 100 Scales on Twigs.			Effect of treatment on trees.
				Winter-killed.	Killed by treatment and winter.*	Alive after treatment.	
Peach -----	2	Badly infested.		00	98	2	No injury.
Japan Plum.	1	"		00	---	---	"
Cherry -----	1	"	Formula No. 5—	00	---	---	"
Pear -----	2	Slightly infested.	20 lbs. lime.	00	---	---	"
Hawthorn --	1	"	20 lbs. sodium sulphide.	00	96	4	"
Currant ----	3	Moderately infested.	40 galls. water.	00	94	6	"
Gooseberry -	2	"		00	---	---	"
Apple -----	2	"		00	95	5	"
Average--	14				96	4.2	

* Winter had killed none at time of treatment. Probably the mortality is due to both treatment and effect of winter.

sulphide. Then cold water was added and the liquid sprayed upon the trees. This makes a mixture which is ash-grey in

color and does not disfigure the trees and shrubs to which it is applied like the boiled mixture; but it is very caustic in its action, and therefore needs to be handled with more care. Sore spots are formed wherever it strikes the skin and it corrodes the finger nails; therefore face and hands should be well protected if this mixture is to be used.

A few trees on the station grounds were also sprayed during December, using the same formula.

Table II. contains the data connected with these tests.

Results at New Haven.

Most of the trees sprayed with lime and sodium sulphide were on rented land and were destroyed by the tenant on vacating the premises in April. The twigs examined, therefore, were cut during April instead of June, as in most of the other experiments. Nevertheless the percentage of living insects was reasonably small, though probably the winter is partly responsible. Two larger trees (apple) on the station grounds received similar treatment, and though only 5 per cent. of living insects were found in June the trees were fairly well coated with scale-insects in October at the writing of this bulletin.

SPRAYING IN LATE WINTER AND SPRING.

Westville Experiments.

About 150 pear trees were sprayed on March 21 and 24. This is the same orchard that was sprayed last year and described in bulletin 144, page 9. The condition of the trees generally was about the same as last year, except that those treated last season with Bordeaux mixture and plain white-wash were more scaly than was the case a year ago, and also more scaly than the other trees. Nearly all were seriously infested, but had not suffered from winter injury as much as most peach and plum trees in the same region.

March 21 was a bright, still day, becoming cloudy in the afternoon, with a light snow at night and a light drizzle of rain in the forenoon of the 22d.

The boiled mixture (see formula No. 2, page 224) was used on the first five rows, beginning on the northwest side. Hot water and light sulphur flour were added to the hard finishing

TABLE III.—WESTVILLE EXPERIMENTS, MARCH 21-24, 1904.

Experiment numbers.	Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Alive after treatment. Average percentage.	Effect of treatment on trees.
1-15	Pear.	50	Majority badly infested.	Formula No. 2— 14 lbs. lime, 14 lbs. sulphur, 40 galls. water.	7.7	No injury by spray. Some injury by scale and winter.
16-27	"	40	Majority badly infested.	Formula No. 9— 14 lbs. lime, 6 lbs. sulphur, 6 lbs. sodium sulphide, 40 galls. water.	6.1	No injury by spray. Some injury by scale and winter.
28-38	"	40	Majority badly infested.	Formula No. 10— 14 lbs. lime, 11 lbs. sulphur, 11 lbs. sodium sulphide, 40 galls. water.	4.4	No injury by spray. Some injury by scale and winter.
39-42	"	10	Majority badly infested.	Formula No. 14— 14 lbs. lime, 14 lbs. sulphur, 7 lbs. caustic soda, 40 galls. water.	4.3	No injury by spray. Some injury by scale and winter.
43-46	"	10 — 150	Majority badly infested.	Formula No. 12— 8 lbs. caustic soda, 40 galls. water.	10.7	No injury by spray. Some injury by scale and winter.

lime and the mixture well stirred until the lime was thoroughly slaked. It was then boiled for 45 minutes in a feed cooker corresponding to a kettle over a wood fire. This outfit is shown on plate V, b. The next eight rows were sprayed with lime, sulphur and sodium sulphide, four receiving formula No. 9, and four formula No. 10. One row was sprayed with lime, sulphur and caustic soda (Formula No. 14) and one row with the caustic soda solution (Formula No. 12).

Results at Westville.

These spraying tests show the boiled lime and sulphur mixture to be no more efficient in destroying the scale-insects than similar mixtures containing lime and sulphur and prepared without boiling. Apparently there was not much difference in the adhesive qualities of these mixtures. When twigs were cut in June for final examination, the whitish coating could be seen, especially on the under sides of the branches of all the trees, except, of course, those receiving the caustic soda solution containing no lime. Caustic soda solution as used here (1 lb. in 5 gallons water) was less effective in destroying scale than any of the lime and sulphur mixtures. (See Table III.)

None of the pear trees of the orchard showed any injury that could be ascribed to the spraying, though some branches were killed by scale and winter. When examined October 22, most of the trees had made good growth and there were few scales on the new wood, though the old wood was well covered with dead ones. The trees sprayed with the caustic soda solution were far more scaly than any of the others. There was but little difference in effectiveness between formulas No. 2, No. 9, No. 10 and No. 14, though No. 9 was probably the least efficient.

Wallingford Experiments.

The trees sprayed at Wallingford were seven years old, of good size, and but slightly infested with the San José scale-insect. The damage to the trees by the winter was slight. The applications were made April 8. Ninety trees were sprayed, using the following formula (No. 9):

14 lbs. fresh finishing lime.	6 lbs. sodium sulphide.
6 lbs. flowers of sulphur.	40 galls. water.

The materials were weighed out, the lime placed in a barrel and just enough cold water added to start it slaking. When the lime began to slake, the sulphur and sodium sulphide were added and the mixture kept well stirred. Just enough cold water was added to prevent the lime from becoming dry or "burning," thus keeping the mixture hot in order to dissolve the sodium sulphide, and as much of the sulphur as possible. After the lime had slaked, a small amount of water was added and the mixture allowed to stand for at least twenty minutes, with occasional stirring. It was then dipped out, strained and diluted. This preparation was of a dark muddy olive-green color, becoming greenish yellow when diluted. Upon straining this into the pump barrel no more sediment remained than with the boiled lime and sulphur mixture.

The spraying outfit consisted of a No. 6 "Hardie" pump mounted on the side of a fifty-gallon barrel. The trees were covered thoroughly. Upon drying, the coating was not as white as on the trees sprayed with the boiled mixture (Formula No. 3). This, of course, was due to the smaller amount of lime used in our mixture and the darker color which the sodium sulphide imparted to it.

About forty trees in the same block were sprayed with a mixture made after formula No. 10.

This was prepared in the same way as the above mixture. The additional amount of sulphur and sodium sulphide made very little difference in the appearance of the mixture, making it a trifle darker in color. The following table gives the chief data:

Results at Wallingford.

Though 130 trees were sprayed here by the writers, the owners of the orchard sprayed the remaining 9,000 trees with boiled lime and sulphur mixture, using for the most part formula No. 3. (See page 224.) Their work was done with thoroughness and twigs were cut from some of the trees for comparison with our tests. The mixture made after formula No. 9 did not appear to stick on the trees as well as the boiled mixture, and the figures show that it was less effective as a scale-destroyer; though where more sulphur and more sodium sulphide were used (No. 10) the results were much better; the average number of surviving scale-insects being smaller even than where the boiled mixture was used.

TABLE IV.—WALLINGFORD EXPERIMENTS, APRIL 8, 1904.

Experiment numbers.	Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Alive after treatment. Average percentage.	Effect of treatment on trees.
55-60	Peach.	90	Slightly infested.	Formula No. 9— 14 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water.	9.5	No injury by spray. Slight injury by scale and winter.
61-65	"	40	"	Formula No. 10— 14 lbs. lime. 11 lbs. sulphur. 11 lbs. sodium sulphide. 40 galls. water.	2.4	No injury by spray. Slight injury by scale and winter.
—	Peach and Japan Plum.	9000*	A few badly infested; most of them slightly infested.	Formula No. 3— 20 lbs. lime. 14 lbs. sulphur. 40 galls. water.	3.9	No injury by spray. Slight injury by scale and winter.

* These trees were thoroughly sprayed by the owners, and do not form a part of our experiments except as a basis for comparison of results.

The orchard was examined on October 26, and the trees were found to be in a very satisfactory condition. It was difficult to find living insects on any of the sprayed trees in the orchard.

Experiments at Southington.

The small peach orchard sprayed last year and described on page 14 of bulletin 144 should be mentioned here. That half of the orchard receiving lime and sulphur mixtures remained quite free from scale, and though the trees suffered injury from the winter, were in much better condition than the trees in the other half of the orchard where whitewash was used and kerosene emulsion applied in August. The whitewashed trees went into the winter in a badly infested condition and were killed, or injured to such an extent that they were cut out in the spring. Twigs and branches were dead.

The remaining trees, 100 in number, were sprayed on April 4 and 5. Seventy received boiled lime and sulphur. (See formula No. 2, page 224.) The other trees were sprayed with lime, sulphur and sodium sulphide, 18 with formula No. 9, and 12 with formula No. 10.

A much larger peach orchard at Spring Lake farm, owned by Mr. L. V. Walkley, was found to be seriously infested by the scale-insect, and though winter injury was at first apparent it was considered a good place for experimentation, and about 950 large trees and 1,500 small ones were sprayed with various mixtures April 4-19. The boiled mixtures were cooked with steam from the boiler of a Kinney "Safe" portable engine. The data are presented in Tables V. and VI.

Results at Southington.

The percentage of living insects shown in Tables V. and VI. are all low and would indicate that the mixtures were efficient had not the winter killed such a large proportion of the scales. On the whole, the mixtures adhered well to the trees and could be seen on the trunks and larger branches when the twigs were cut in June. The boiled mixtures remained perhaps longer than those made without boiling, though the differences were not great. The effect of the winter on this orchard makes it difficult to draw any accurate conclusions regarding the efficiency of the various mixtures used. It seems safe to say, however, that the spread of the scale was greatly checked by

TABLE V.—SOUTHINGTON EXPERIMENTS, APRIL 4-19, 1904.

Experiment numbers.	Kind of trees.	Number of trees treated.	Conditions of trees before treatment.	Materials applied.	Alive after treatment. Average percentage.	Effect of treatment on trees.
51	Peach.	70*	Slightly infested.	Formula No. 2— 14 lbs. lime. 14 lbs. sulphur. 40 galls. water. Formula No. 10— 14 lbs. lime. 11 lbs. sulphur. 11 lbs. sodium sulphide. 40 galls. water. Formula No. 9† 14 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water. Formula No. 2— 14 lbs. lime. 14 lbs. sulphur. 40 galls. water. Formula No. 3— 20 lbs. lime. 14 lbs. sulphur. 40 galls. water. Formula No. 7— 20 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water.	6.9	No injury by spray. Some winter injury.
52	"	12*	"		4.9	No injury by spray. Some winter injury.
53	"	18*	"			No injury by spray. Some winter injury.
72-104	"	322	Seriously infested.		2.9	No injury by spray. Some winter injury.
105-134	"	1962†	"		4.2	No injury by spray. Some winter injury.
135-169	"	128	"		2.1	No injury by spray. Some winter injury.

* Barnes orchard. These trees were sprayed last year.

† 1500 were small trees slightly infested.

TABLE VI.—SOUTHINGTON EXPERIMENTS, APRIL 4-9, 1904.

Experiment numbers.	Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Alive after treatment. Average percentage.	Effect of treatment on trees.
158-159	Peach.	12	Seriously infested.	Formula No. 11— 20 lbs. lime.	3.6	No injury by spray. Some winter injury.
				14 lbs. sulphur.		
				6 lbs. sodium sulphide.		
				40 galls. water.		
163-172	"	28	"	Formula No. 8— 20 lbs. lime.	2.4	No injury by spray. Some winter injury.
				11 lbs. sulphur.		
				11 lbs. sodium sulphide. 40 galls. water.		

the treatment and that all the mixtures here used were fairly efficient. The final examination made on October 26 showed the trees to be almost free from scale, though the winter injury was more serious than was supposed early in the season.

Experiments at Milford.

On April 22-23, various mixtures prepared without boiling were applied to 217 fruit trees and 256 currant bushes at Milford. The spraying season was nearly at an end and the buds were opening on plum trees, currant and gooseberry bushes. The lime, sulphur and sodium sulphide mixture (formula No. 7), lime and potassium sulphide (formula No. 4), lime, sulphur and caustic soda (formula No. 15), and caustic soda solution (formula No. 13), lime and sodium sulphide (formula No. 6) were used in these tests.

Most of the trees and bushes were moderately infested with scales, and some were killed or injured by the winter, so that leaves did not start from the branches. In some cases growth started from the upper portion of the trunks.

Data connected with these experiments are given in the accompanying table.

Results at Milford.

Trees sprayed with mixtures No. 4 and No. 15 gave the lowest percentage of living insects in June. Those receiving No. 6 and No. 13 gave the highest. No. 6 probably washed off sooner than the other mixtures containing lime, though there was little difference in this respect between 4, 7 and 15. Though no boiled mixture was employed here for comparison, it certainly seems as if mixtures Nos. 4 and 15 gave about as good results as could be expected of a boiled mixture. The sprayed trees were examined October 25. Formulas Nos. 7, 4 and 15 gave very satisfactory results, the new growth of the trees being mostly clean. Nos. 6 and 13 were less efficient and more living scales were found on trees sprayed with these preparations.

CONNECTICUT ORCHARDS SPRAYED IN 1904.

It is safe to say that over 100,000 fruit trees in orchards and gardens were sprayed in Connecticut during 1904 with the lime and sulphur mixtures. Mr. J. H. Hale sprayed about

TABLE VII.—EXPERIMENTS AT MILFORD, APRIL 22-23, 1904.

Experiment numbers.	Kind of trees.	Number of trees treated.	Condition of trees before treatment.	Materials applied.	Alive after treatment. Average percentage.	Effect of treatment on trees.
175-181	Japan plum. European plum. Cherry. Pear. Currant.	20 135	Moderately infested.	Formula No. 7— 20 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water.	6.2	No injury by spray. Some injury by scale and winter.
182-187	Peach. Plum. Currant.	11 36	"	Formula No. 4— 20 lbs. lime. 20 lbs. potassium sulphide. 40 galls. water.	2.3	No injury by spray. Some injury by scale and winter.
188-195	Pear. Plum. Currant.	6 20 70	"	Formula No. 15— 20 lbs. lime. 14 lbs. sulphur. 5 lbs. caustic soda. 40 galls. water.	1.8	No injury by spray. Some injury by scale and winter.
196-201	Peach. Pear } Apple }	11 14	"	Formula No. 13— 7 lbs. caustic soda. 40 galls. water.	8.9	No injury by spray. Some injury by scale and winter.
202-204	Plum. Currant.	8 150	"	Formula No. 6— 20 lbs. lime. 10 lbs. sodium sulphide. 40 galls. water.	10.7	No injury by spray. Some injury by scale and winter.

16,000 trees in his orchards at Glastonbury and Seymour; Mr. C. E. Lyman sprayed 12,000 trees at Middlefield, and it has already been mentioned that the Highland Fruit Co. of Wallingford sprayed their entire orchard of 9,000 trees. Other growers who have done more or less spraying with the lime and sulphur mixture are A. C. Sternberg, West Hartford; C. I. Allen, Terryville; T. H. & L. C. Root, Farmington; Barnes Brothers, Yalesville; A. E. Plant & Son, Branford; G. F. Platt & Son, N. D. Platt & Son, Milford; Hall & Barnes, Wallingford, and many others.

In Keney Park, Hartford, a great deal of spraying was done in the ornamental planting of trees and shrubbery, and the writers are informed that the lime and sulphur mixture is considered preferable to any of the oils or soaps previously used here for the purpose of killing the scale.

So far as can be learned, the results of this spraying work have been on the whole satisfactory. The boiled mixture has been used in most cases, and the work done in the spring. The care with which the mixtures are made and applied, the condition of the trees, and the climatic conditions all affect the final results.

MAKING THE BOILED MIXTURE.

A portable steam boiler is probably the most convenient outfit for cooking the lime and sulphur mixture for the average orchard. The boiler can be set up in the orchard, preferably near a water supply, and the mixture cooked in open barrels. Common rubber hose is more convenient than iron pipe for conveying the steam to the barrels, as it can be removed more readily. The mixture can then be applied as fast as it is made. Each line of hose should be fitted with a valve. If there is no spring or stream of water near the orchard it is not impracticable to cart water to the boiler, as was done at Wallingford by the Highland Fruit Co., or to cart the boiled mixture a mile or more from the boiler to the orchard. Mr. Plant of Branford cooked the spraying mixture near his house, drawing water in a spout directly into the cooking vats from a spring on the hillside. From the boiler the mixture was carted in tight casks into the orchard about a mile distant, drawn off into the spray barrels and applied. The portable boiler can

be used in any moderate sized orchard, but is capable of cooking material for large orchards. The Kinney "Safe" engine with boiler is a common source of power on Connecticut farms, and this has probably been used more than any other forms of portable boilers for cooking the mixture, and has been very satisfactory; one of 5 h. p. capacity furnished steam to cook all of the mixture used in spraying 9,000 good sized peach trees in the orchard of the Highland Fruit Co. at Wallingford. An outfit of similar size and pattern was used in an orchard of 12,000 trees by Mr. C. E. Lyman of Middlefield. Some of the largest orchards, however, are provided with more permanent stationary cooking plants. That of Barnes Brothers of Yalesville has already been described and figured in the Report of this Station for 1902, page 120. A much more elaborate outfit has been devised by Mr. J. H. Hale of South Glastonbury. (See plate VI, a.) Mr. Hale's plant consists of a horizontal boiler of 20 h. p. connected by pipes with eight barrels in which the materials are boiled. Above each barrel the steam pipe has a valve, and at the bottom of the barrel the pipe is fitted with a 4-way connection containing short pipes drilled with small holes for the escape of the steam. By this arrangement no stirring is necessary. The bottom of each barrel is also connected by pipe to the water supply, and by means of valves the boiled mixture can be diluted, and drawn off through the same pipes into the spray barrel or into casks to be carted away. This appears to be a good type of a large cooking plant and has a capacity of about 50 barrels of mixture per day.

It is not essential, however, for the owner of a small orchard to go to the trouble and expense of fitting up an elaborate outfit of this sort. Neither is it necessary to employ the portable boiler, as the mixture can be cooked very satisfactorily with steam from the heating plant of the house; in a set kettle or portable feed cooker, such as are in use on many farms, or even in a kettle on the stove, where small quantities are required. A feed cooker used in our Westville experiments is shown on plate V, b.

Finishing lime should be used where possible, as this slakes completely, leaving little sediment to clog strainer and nozzles. It comes in hard white lumps, costs more than mortar lime and generates more heat in slaking. It is important that the lime

should be properly slaked, for upon this depends in a large measure the amount of sediment. Water should be added to the lime only as needed to prevent burning. Lime needs air as well as water in order to slake well. Therefore too much water will hinder the slaking process or "drown" it, as the bricklayer says. Constant stirring is also required to prevent "burning" in spots. The weight of the lime should equal or slightly exceed that of the sulphur. A great excess injures the mixture, causing it to flake off from the trees. Sulphur should be used either in the form of the sublimed "flowers," or the finely ground "light sulphur flour." The particles are somewhat smaller in the sublimed product, but there is a greater tendency to become lumpy under pressure and this, of course, retards solution. The writers believe that the light flour is the better, all things considered.

The sulphur should be added to the lime before slaking, as the heat of the slaking lime can be utilized to help dissolve the sulphur, though this heat alone will probably dissolve only a small portion of it. It is well to stir the materials thoroughly during the slaking process to prevent "burning" of the lime. Water should be added as needed, and after the lime is slaked the barrel can be filled about one-third full of water and the steam or heat applied. The mixture should boil for a period of time varying from forty-five to sixty minutes. Of course, the heat can be applied during the slaking process, and in this case it should be turned on for at least an hour to make sure that the sulphur is well dissolved. In our Bridgeport experiments, the sulphur was made into a paste by working it over with the hands, warm water being used. This prepared the sulphur for more immediate action, and the materials were boiled only thirty minutes and very little or no sulphur remained undissolved. But in most cases it will be found more economical to add dry sulphur to the slaking lime and boil it for a longer time. There should not be more than a pint of sediment for each barrel of mixture if properly made, and the mixture should be strained when put into the spray barrel.

Salt may be added to this mixture and is still used in some orchards, though in most cases it is omitted. In previous tests conducted by us and by many other experimenters, salt was found to have no value either in making the mixture more

adhesive or in rendering it more destructive to the scale-insects.

MAKING THE MIXTURE WITHOUT BOILING.

The fact that the ordinary lime and sulphur mixture requires boiling has kept many from using it, in spite of the small cost of the mixture, even when boiled. In large orchards, where suitable outfits can be procured, the question of boiling is not such a serious one, but in hundreds of small orchards and gardens the trees would be sprayed if some easily made mixture could be used. There is a demand for a mixture that can be prepared without hot water, and this has prompted us to try several things with the view of possibly supplying this demand.

Last year we used potassium sulphide and found it a valuable addition to our list of scale insecticides. It has been used the present season with good results. It is too expensive for large spraying operations, but is very convenient for spraying a few small trees or shrubs near the buildings or in a city yard. Knowing that sodium compounds are usually cheaper than potassium compounds, and have similar properties, we sought the former, and through considerable correspondence we learned that two grades of sodium sulphide could be obtained at a low price. The crystallized form contained less than 30 per cent. of sodium sulphide and cost $1\frac{3}{4}$ cents per pound in 500 lb. barrels. The fused form has nearly 60 per cent. of sodium sulphide and costs $2\frac{3}{4}$ cents per pound in drums of over 700 lbs. Both kinds were tested in the laboratory and mixtures with lime were made from each and sprayed upon trees. The mixture from the crystallized sulphide did not stick as well as that from the fused, and as it contained such a small quantity of sodium sulphide, was not employed extensively. The fused sulphide, however, promised to be of value and was used quite extensively in these experiments. The worst feature about it is the form in which it comes—in a fused mass, hard as a rock. When freshly broken it is of a reddish color, resembling the mineral cinnabar. On exposure to the air it soon blackens and gives off a strong odor of sulphuretted hydrogen. The large lumps are hard to dissolve, but the finely pulverized material is very soluble in cold water. The entire mass was broken with hammers into

small pieces—no larger than a hen's egg. In this form it would nearly all dissolve when added to the slaking lime, but in uniting with the lime to form calcium sulphides caustic soda was also formed, and the mixture was so very caustic that it went through the skin, making sore spots wherever it struck. In our laboratory tests the dissolved sodium sulphide was found to be an excellent solvent of sulphur, exceeding caustic soda when in cold solution, though the latter would dissolve more sulphur if heated. In discussing the properties of this sodium sulphide, Director Jenkins suggested to the writers that by using this as a solvent for sulphur in connection with lime, the causticity would probably be much reduced—which was found to be the case.

An effort then was made to prepare a mixture without boiling based on the same cost of materials as the boiled mixture. Formula No. 7 is the result, and No. 8 was simply a test of larger quantities of sulphur and sodium sulphide with the same amount of lime. When prepared after either formula, this mixture is no more caustic or unpleasant to handle than the boiled lime and sulphur mixture, and while we are not yet prepared to state that it is just as good, it certainly has given favorable results that warrant further trial. If this sodium sulphide could be obtained in pulverized form it would be much more convenient to use, and we have taken up the matter with the manufacturers in Germany to try and bring it about.

This 60 per cent. sodium sulphide can now be obtained in crushed form from the Roessler & Hasslacher Chemical Co., 100 William street, New York City, and doubtless from other dealers. It is packed in iron drums holding 110 pounds each and costs $3\frac{1}{2}$ cents per pound F.O.B. at New York. The price may vary somewhat, but is sufficiently low to make the preparation an inexpensive one to use in orchards.

In making the mixtures without boiling, the unslaked finishing lime was used. This generates more heat in slaking than the mortar lime, and heat aids in dissolving the sulphides. The best solution resulted when the greatest amount of heat was produced by the slaking lime. The light sulphur flour is the grade of sulphur best adapted for the unboiled solutions. As has already been mentioned, this does not form as many dry

lumps as the flowers of sulphur. Boiling will break up some of these lumps, but it is more necessary in the unboiled mixture to use the form that is least inclined to become lumpy.

Cold water was used in most cases. Warm, or hot water, of course, assists greatly in slaking the lime and dissolving the sulphides. But it requires nearly as much of an outfit to heat the water as to boil the lime and sulphur mixture, and the chief object of an unboiled mixture is to do away with such an outfit.

Lime and Potassium Sulphide Mixture.

Formula No. 4. $\left\{ \begin{array}{l} 20 \text{ lbs. lime.} \\ 20 \text{ lbs. potassium sulphide.} \\ 40 \text{ galls. water.} \end{array} \right.$

This can be prepared in two ways, either of which is satisfactory.

1. Place the weighed potassium sulphide in a half-barrel and add three or four pails of water. Stir occasionally. Place the lime in a barrel and slake carefully, the same as for a boiled mixture. When the potassium sulphide has all dissolved add it to the slaked lime, with water to make about one-third the required volume. Then strain the mixture into the pump barrel, dilute to make the right proportion and apply to the trees.

2. Weigh out the materials. Put the lime in a barrel and start it slaking. When it begins to slake vigorously add the dry sulphide. Then stir the mixture vigorously and add just enough water to keep the lime from burning. After the lime has slaked, add a small quantity of water and allow the mixture to stand for a short time, with frequent stirring. Then dilute and apply.

The above formula has been given in several Experiment Station bulletins with directions that the potassium sulphide be dissolved in warm water and the lime slaked with this solution. We do not recommend this method, because the sulphide when dissolved makes a soapy, caustic solution which, when added to the lime, immediately coats over the lumps, excluding the air and checking the slaking process. Besides, there is practically nothing gained by this method.

Lime, Sulphur and Sodium Sulphide Mixture.

No. 5. {	20 lbs. lime. 20 lbs. sodium sulphide. 40 galls. water.	No. 8. {	20 lbs. lime. 11 lbs. sulphur. 11 lbs. sodium sulphide. 40 galls. water.
No. 6. {	20 lbs. lime. 10 lbs. sodium sulphide. 40 galls. water.	No. 9. {	14 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water.
No. 7. {	20 lbs. lime. 6 lbs. sulphur. 6 lbs. sodium sulphide. 40 galls. water.	No. 10. {	14 lbs. lime. 11 lbs. sulphur. 11 lbs. sodium sulphide. 40 galls. water.

These mixtures are made practically in the same way as the last preparation. It is important to use as little water as possible in slaking the lime and to let the lime get well started before the other ingredients are put in.

Weigh the materials, put the lime in a barrel, add water, and when it begins to slake vigorously add the dry sulphur and lumps of sodium sulphide. Keep the whole well stirred. When the lime is slaked, add a few pails of water, and let the solution stand for about twenty minutes. It can then be strained, diluted, and sprayed upon the trees. The sodium sulphide used in these mixtures is dissolved by the water, aided by the heat of the lime. The caustic properties of the sulphide and lime, together with the heat, dissolve the sulphur flour, thus forming sulphides of lime similar to those formed in a boiled lime and sulphur mixture.

This appears much like the regular boiled mixture, except that it is olive-green in color instead of yellow.

Lime, Sulphur and Caustic Soda.

Formula No. 14. {	14 lbs. lime. 14 lbs. sulphur. 7 lbs. caustic soda. 40 galls. water.
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In this mixture caustic soda is added to assist in dissolving the sulphur. Start the lime slaking and add the sulphur and caustic soda. The caustic soda causes violent boiling of the mixture, and water must be added at intervals to prevent the mixture from boiling over the top of the barrel. The mixture becomes reddish in color very soon after adding the caustic soda, and by the time the action ceases the color reaches deep reddish brown. Then dilute with water and apply. This mix-

ture is convenient and effective. Common household lye can be used instead of caustic soda.

This is similar to the mixture originated at the New York (Geneva) Experiment Station and used extensively there in the orchards. (See Bulletins 228 and 247 N. Y. Expt. Station, Geneva, N. Y.)

The outfit required for making the self-boiled mixtures is shown on plate IX.

Caustic Soda and Water.

No. 12. { 8 lbs. caustic soda. 40 galls. water.	No. 13. { 7 lbs. caustic soda. 40 galls. water.
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Dissolve the weighed amount of caustic soda in water and dilute ready for use. This solution is very disagreeable to use; every drop that strikes the skin makes it smart violently.

OUTFIT FOR APPLYING THE MIXTURE.

Spraying with the lime and sulphur mixture is looked upon as one of the arduous and disagreeable jobs of the fruit grower. The spring spraying comes at a time when each day brings the grower nearer the regular spring work. Especially if a few days of bad weather occur, the spraying must be rushed as fast as possible. The above reasons alone are sufficient to show that the best and most practical outfit procurable should be used, to make the work go as smoothly and pleasantly as possible and to obviate the loss of time from the breaking down and the giving out of an inadequate spraying outfit.

As spraying is more and more practiced, the good and bad points of spray pumps and their accessories are being brought out.

Many inquiries have come to the station during the past year in regard to the best kinds of spray pumps, nozzles, etc. It seems, therefore, advisable to describe a practical outfit in this report.

Pump, Barrel and Carriage.

It has not yet been demonstrated that power sprayers are as practical or can take the place of the hand barrel pump for orchard work in Connecticut. The first thing to consider is the pump, which should be of large size, furnishing ample

pressure to supply at least two lines of hose fitted with double Vermorel nozzles. This should be made so that when it is mounted on the end of a fifty gallon cask, the highest point should be the fulcrum or post on which the pump handle or lever works. This should be just high enough to give the handle a good working distance,—that is, when pushed down it will just clear the chine of the barrel. The air chamber should be under the handle post, the larger part of it being in the barrel out of sight. It is essential that the cylinder be of good size and the plunger must be packed in such a manner that it can be tightened quickly and easily. The valves should be made as simple as possible. It must be possible to take the whole pump apart and put it together with a monkey wrench. The lime and sulphur mixture requires a pump with an agitator that will keep the liquid well mixed. In purchasing a pump for applying these mixtures it is better to select one with iron cylinder because it is less expensive than a pump made entirely of brass and corrodes less rapidly. All pumps are made with brass working parts. Three types of pumps are shown on plate VII.

There are several pumps on the market which are of this type. One which has recently been brought to the attention of the Connecticut fruit grower is the "Hardie." This pump has several features worth pointing out. The plunger is made so the packing can be tightened by turning the plunger rod with a wrench without removing it from the cylinder. The plunger consists of two cone-shaped pieces, one screwing upon the other; the groove between them is wound full with cotton waste. This is pushed into the cylinder and a projection on the lower cone holds it stationary while the upper one is screwed down by turning the rod. This crowds the packing together until it fills the cylinder. The mixture enters the pump through a strainer at the side instead of the bottom, and the agitator works up and down in front of this place, keeping the strainer from becoming clogged.

Among the pumps used in Connecticut that have given fairly good satisfaction are the "Eclipse," manufactured by the Morrill & Morley Co., Benton Harbor, Mich.; the pumps manufactured by the Goulds Mfg. Co., Seneca Falls, N. Y., of which the "Pomona" is a type; and the "Century," manufactured by

the Deming Co., Salem, Ohio. These pumps all have some good features as well as weak ones. All pumps should be made so that they can be removed from the barrel more readily.

Plate IV, b, shows one of the most practical ways of mounting a pump. The pump is mounted on the side of the barrel instead of the end. One can readily see many advantages in this method. The barrel is less liable to tip over in rough places. It is much easier to fill than when mounted on the end. When a strainer like the one described is used a hole only large enough to take in the pipe is necessary in filling the barrel. This can be plugged tightly. A drag or sled is made of two pieces of 4 x 6 inch scantling for runners, and spiking a platform of plank to the upper edge of them. The front ends of the runners are rounded. The barrel is placed crosswise of this sled on wooden blocks cut to fit the curve of the barrel and fastened to both barrel and sled. There should be standing room behind the barrel for the man who pumps. A piece of scantling is placed close to each side of the barrel and fastened to the wooden blocks, thus forming a frame around the barrel, securely fastening it to the sled. Iron straps may also be used for holding the barrel in place. Plate IV, b, shows two pumps. One is mounted in the manner just described, the other is placed lengthwise of the runners. It took but a short time to prove which was the practical way of mounting. Where it was mounted lengthwise there was more chance for the barrel to tip over. The handle was at the side and liable to catch on the trees and branches in going through the orchard. The man pumping was continually in the way of the hose on one side. The hose leads from the back and front of the outfit instead of the sides, as in the other case, consequently the hose was continually bent at the point of attachment and soon gave out.

When the barrel was mounted crosswise of the drag, the man pumping stood back on the platform out of the way of the men handling the hose.

Pump manufacturers make outfits consisting of small-sized barrels holding from 15 to 25 gallons, mounted on wheels, for hand use in the garden. The ordinary barrel pump is used in these outfits, though sometimes of a smaller size than would be chosen for orchard work. These hand wheel outfits are most useful in the home garden of four or five acres. (See plate

VII, b.) For still smaller places, like the ordinary city yard, or for spraying a few large trees, a bucket pump costing from four to six dollars is perhaps the best form of outfit. Such a pump is shown on plate VIII, c, and can be used with any wooden pail or bucket. The small compressed air pumps on the market, and the knapsack pumps, will answer the purpose, but most of them are badly corroded by the lime and sulphur mixtures.

Clean water should be run through pump, hose and nozzles at the end of each day's work, and at the end of the spraying season the pump and nozzles should be well cleaned and oiled to prevent corrosion.

Hose.

For general spraying work, we prefer half-inch rubber hose in lengths of not less than 25 feet. Where two lines of hose are used it is frequently of advantage to have one of them 50 feet long for reaching the opposite side of trees or for working a long distance behind the pump. Most of the pumps are sent out with a piece of hose seven or eight feet in length, which is altogether too short for practical work. This hose, though of good quality, usually costs 16 or 18 cents per foot, making it too expensive for orchard use. We have been using a grade of hose which can be purchased from the rubber stores in the larger cities of Connecticut for eight or nine cents per foot. This hose has been very satisfactory, withstands the pressure, and for dragging about in the orchard seems to wear about as long as the more expensive hose. The points of breakage are always near the ends where sharp bending occurs.

The ready-made devices for fastening the hose to its connections are not satisfactory for spraying work. We much prefer number 16 soft iron wire, which can be obtained from any hardware store at five cents per coil. This is just the thing for wiring the hose to the connections. For this purpose a coil of wire and pair of cutting pliers should always be carried in the pocket of at least one of the men connected with each spraying outfit.

Extension Rods.

For reaching into the trees it is necessary to use some form of rod six to ten feet long, and the lightest and best is a hollow one which screws onto the end of the hose and permits

the liquid to pass through it. Bamboo rods have been designed for this purpose, each consisting of a brass tube inside of a piece of bamboo. Screw connections are made between the brass rod and the hose at one end, while the other end takes the nozzle. The hose connection should also have a stop cock or "shut off" to avoid wasting the spray mixture. The bamboo extensions are light and convenient, but not durable, as the screw connections soon break off or the bamboo splits or becomes loosened on the brass rod. For this reason many orchardists have adopted an extension made of quarter-inch gas-pipe. Though heavier and harder to hold in the hand on account of the smaller diameter, the gas-pipe rods are more durable and considerably cheaper than the bamboo extensions.

Nozzles. •

The double Vermorel nozzle has been used probably more than any other in orchard spraying and has given satisfaction. For large trees the MacGowen is preferred by some operators. During the past season the Goulds Mfg. Co. has put upon the market a new nozzle called the "Mistry." The "Mistry" is a large and somewhat complicated nozzle that gives a fine spray. Formerly the caps wore out very quickly and often needed replacing once or twice each season, but now these nozzles are made with a hardened steel disk containing a hole through which the liquid passes. The lime and sulphur mixture, when forced in a thin stream under great pressure against the cap, will soon wear and enlarge the opening on any of these nozzles. If the caps could be made of hard steel instead of brass, they would last much longer. Some growers praise the "Mistry" highly, while others prefer the double Vermorel. The Spramotor Co. has originated a nozzle fitted with hard steel disks, through which the openings are made. These disks can be replaced easily and while we have not yet given these nozzles a practical trial in the orchard, they appear to work nicely and throw an excellent spray. One man who makes a business of spraying trees informs me that the Spramotor is the best nozzle that he can find for his work. The nozzles of the "Bordeaux" and "Seneca" type give a fan-shaped spray, are heavy and not readily cleaned after being set, and the handles are hook-shaped and get caught in the branches. For these reasons they are not

well adapted to orchard work. These nozzles are all shown on plate VIII, a.

Strainer and Funnel.

We have found a home-made strainer the most satisfactory, as the ready-made strainers are not of the proper size or shape for practical use. The strainer and funnel that we have adopted consists of a common wooden pail with the bottom reinforced and a piece of one and one-half inch iron gas-pipe screwed through it. About half-way up on the inside of the pail is tacked a circular piece of iron wire cloth, having at least 20 meshes per inch. A finer strainer is not needed and only hinders the work, as the men must wait for the liquid to go through. This kind of a strainer is always convenient, will hold a pailful at a time, and there is more straining surface than if the wire was placed at the bottom. It is shown on plate VIII, b. The materials for such a strainer cost not more than fifty cents, and the wire cloth can be obtained from the wire stores in New Haven and Hartford. One square foot of this cloth is usually enough for a strainer and costs about fifteen cents.

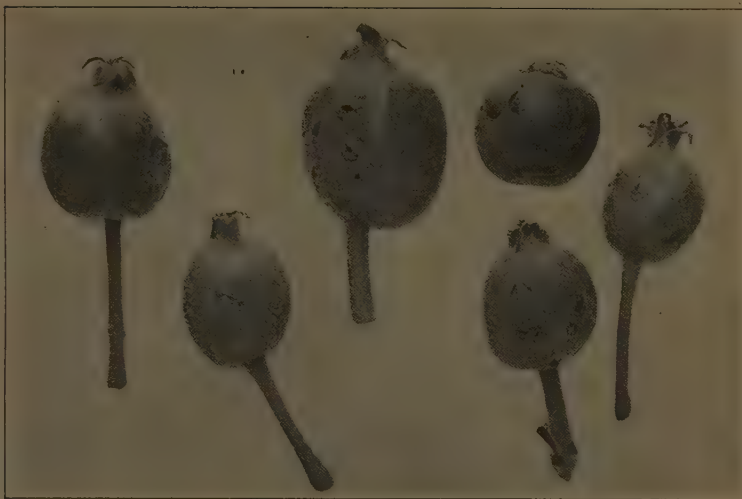
SUMMARY.

1. This station conducted spraying experiments in Bridgeport, New Haven, Westville, Wallingford, Southington and Milford during the past season, to kill the San José scale-insect. Over 4,000 trees were treated. Nearly 800 were sprayed in December and the remainder in March and April. Fifteen different formulas were used in the preparation of the materials; mixtures of lime and sulphur were used chiefly.

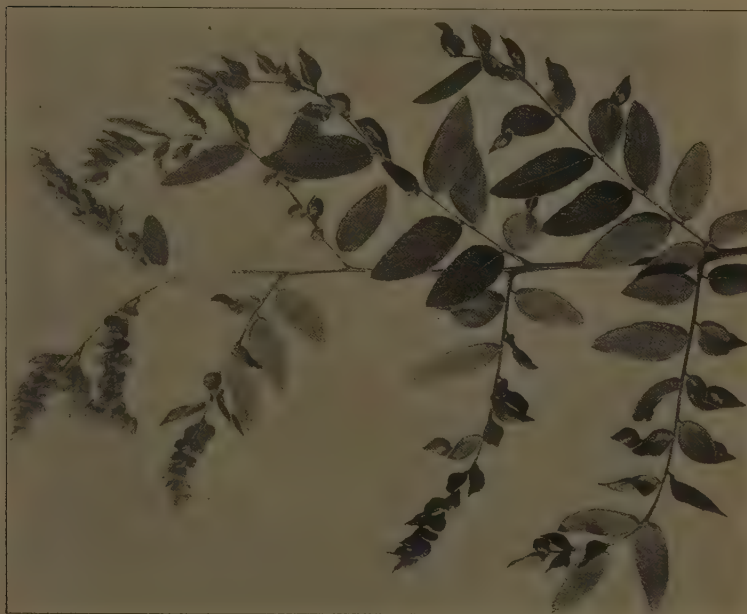
2. The winter injury to trees was very serious, many orchards being permanently damaged. This makes it impracticable to express in exact figures in all cases the results of these experiments. Fifty per cent. of the San José scale-insects were also destroyed by the winter in many localities.

3. Fall or early winter spraying gave good results, both where the boiled and unboiled lime and sulphur mixtures were used, and will doubtless soon be practiced by fruit-growers.

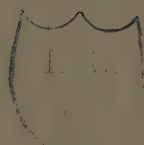
4. The boiled mixture of lime and sulphur, using as much or a little more lime than sulphur, is probably as effective and as inexpensive as any mixture for ordinary orchard work. Of the mixtures made without boiling, the potassium sulphide and lime is excellent for a few small trees or shrubs, but is rather expensive for spraying large trees; the lime, sulphur and sodium sulphide mixture is a promising one, worthy of further trial, and giving good results in these experiments. Lime and sodium sulphide make a mixture that is less efficient than those



a. Young apples showing punctures made by the plum curculio.

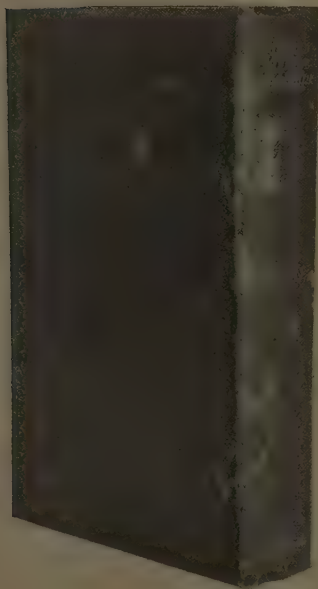


b. Galls on honey locust.





a. Currant leaf injured by *Empoasca mali*: healthy leaf at right.



b. Injury to book by cockroaches.



c. Sawfly larvae on ash.

INSECT INJURIES TO CURRANT, ASH AND BOOKBINDINGS.





a. The noon hour in spraying time. Portable boiling plant and outfits for applying the lime and sulphur mixture.



b. Nearer view showing methods of mounting pump and barrel. The proper method is shown at the right. This is an excellent outfit for a rough orchard.





a. Applying the mixture to infested pear trees.



b. Boiling the lime and sulphur mixture in a kettle or feed cooker.

WESTVILLE SPRAYING EXPERIMENTS.



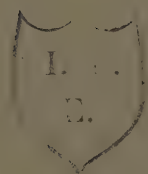


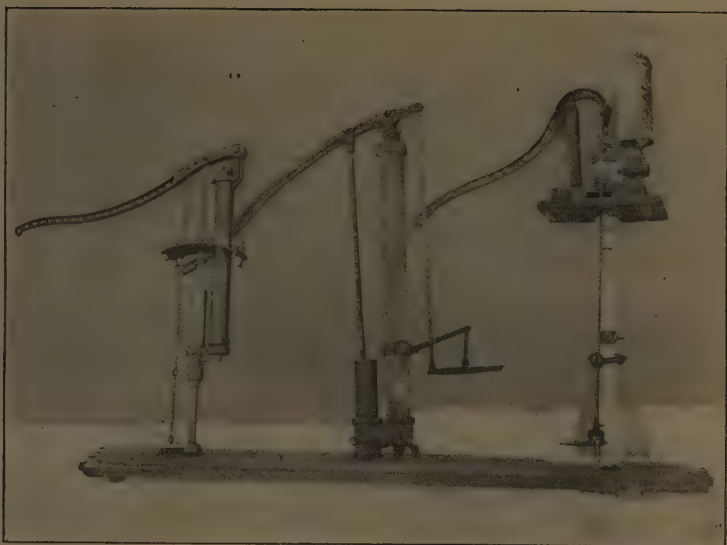
a. Improved stationary cooking plant of J. H. Hale, South Glastonbury.
Capacity of this plant is about 50 barrels of mixture per day.



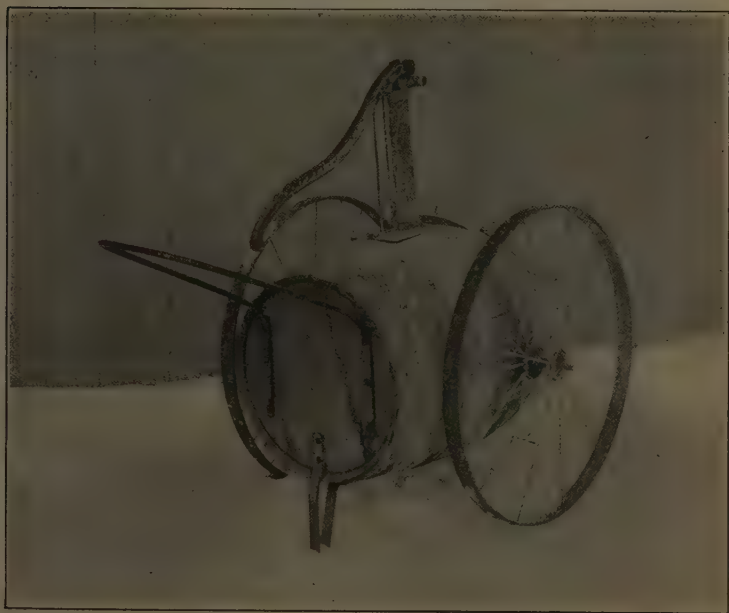
b. The common method in Connecticut orchards. A portable engine with boiler is placed near the orchard where water can be obtained. Steam is conveyed to the barrels through common rubber hose.

STATIONARY AND PORTABLE STEAM COOKING PLANTS.





a. Three types of barrel pumps.

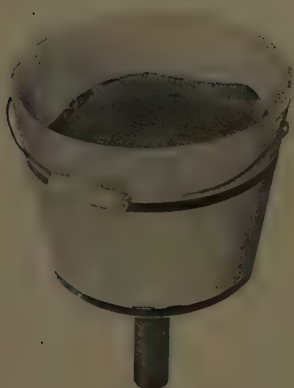


b. A convenient outfit for the garden.

SPRAYING PUMPS.



a. Some spray nozzles in common use. 1. Single Vermorel: 2. McGowen: 3. Bordeaux: 4. Double Vermorel: 5. Mistry: 6. Double Spramotor.



b. An excellent home-made strainer and funnel.

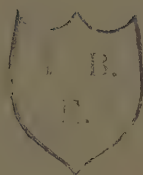


c. Spraying a tree with a bucket pump. This is an excellent outfit for the garden and the city yard.





MAKING THE SELF-BOILED LIME AND SULPHUR MIXTURE.



just mentioned, nearly as caustic in its action as caustic soda, and workmen need protection in handling it. At present sodium sulphide (fused) is put up in a convenient form for orchard use and is inexpensive.

5. Caustic soda as used in these tests did not give as good results as most of the other mixtures. Its caustic action makes it hard to handle and the hands and faces of the men should be protected.

6. Probably 100,000 fruit trees in Connecticut orchards and gardens were sprayed with the lime and sulphur mixtures during the spring of 1904. The results were generally satisfactory.

7. A satisfactory spraying outfit consists of hand pump in barrel mounted on drag or wagon and fitted with two lines of half-inch hose at least 25 feet long, extension rods and nozzles, as described in the foregoing pages.

REPORT ON MOSQUITO INVESTIGATIONS.

BY W. E. BRITTON AND HENRY L. VIERECK.

Recent discoveries have established the fact that certain species of mosquitoes transmit malaria, yellow fever, and filariasis (elephantiasis), and by so doing make these diseases epidemic.

This knowledge has given great importance to the study of mosquitoes; their species, life histories and relations to public health.

In 1896 about 250 species were known in the world,—less than 30 in the United States. Now over 400 species have been described—over 60 of them occurring in this country.

Mosquitoes cannot any longer be regarded merely as producers of irritation or discomfort, but rather as a menace to the health of the community: and a pool where the malarial mosquito breeds is a public nuisance.

Health boards and officers are condemning and destroying the breeding places in thickly settled communities in the interest of the public health, while at the same time many owners of shore property and summer resorts have by the drainage or filling of stagnant pools greatly abated or removed the plague of mosquitoes and thus enhanced the value of their property.

The survey herein described was undertaken in order to learn what species of mosquitoes are found in the state, where are their chief breeding places and what means may be useful in diminishing or entirely abating the mosquito nuisance.

To cover the whole state will require several years' work with the limited means at our command. A beginning has, however,

been made by examining the coast region and the largest centers of population where the nuisance is more seriously felt.

Before describing this survey it will be worth while to notice briefly the evidence regarding the connection of mosquitoes with the transmission of certain diseases.

MOSQUITOES AS CARRIERS OF DISEASE.

Malaria.

*In the year 1880 Laveran, a French army surgeon, discovered in the blood of persons showing symptoms of ague, a peculiar protozoan parasite which he believed to be the cause of the disease, and named *Plasmodium malariae*—the *Plasmodium* of malaria. Within a few years this discovery was confirmed by careful observers all over the world. In 1882 King and others suggested the mosquito as a possible agent in the transmission of the parasite.†

The malarial parasite is found in the red corpuscles of the blood and may be readily demonstrated by spreading a drop of fresh blood from a malarial patient evenly upon a slide and staining with Jenner's, Goldhorn's or Leishman's stains.‡ After entering the human system the parasite develops in the red blood corpuscles and in from 9 to 14 days splits up or sporulates, bursts the blood cell and the segments are discharged into the serum. This is the period at which the malarial spasms (chills and fever) appear and at which quinine is the most efficacious. Some of these segments enter other blood cells heretofore healthy and undergo the same process of development, while others do not divide up in this manner, and though similar in size to the dividing forms, take stains differently and send out flagella or threads after the blood has been drawn from the human body. In 1895 Dr. Patrick Manson of London expressed an opinion that this flagellated form was probably connected with an alternate mode of reproduction which takes place outside of the human body, and considered some blood-sucking

* The greater part of this chapter was taken from a paper read by the State Entomologist before a conference of health officers, at Hartford, December 15, 1903. It will probably be printed in the Report of the State Board of Health.

† L. O. Howard, Mosquitoes, page 48.

‡ W. N. Berkeley, Laboratory Work with Mosquitoes, page 72.

insect (probably a mosquito) the most probable host. Dr. Ronald Ross, an English military surgeon and pupil of Dr. Manson's, afterwards went to India with a strong determination to find that insect. He dissected the bodies of "nearly a thousand mosquitoes," and finally his efforts were rewarded by the discovery of a single specimen (*Anopheles*) which had pigmented bodies in the stomach wall after having bitten a malarial patient. Since then it has been learned through many investigations by patient workers in different parts of the world, that a definite development of the flagellated form takes place within the body of the malarial mosquito. Small capsules are formed upon the wall of the stomach and these increase in size for six or eight days, finally bursting and discharging a great number of sickle-shaped bodies into the body cavity of the insect. These sickle-shaped bodies finally reach the poison gland and some escape into the blood of the person next bitten by this mosquito. The victim usually becomes ill in about fourteen days after being bitten.

Evidence of the transmission of malaria by mosquitoes is briefly as follows:

Doctors Sambon and Low of the London School of Tropical Medicine constructed in 1900 a five-room wooden house in one of the worst malarial sections of the Roman Campagna. The house was thoroughly screened to keep out mosquitoes, and the occupants went inside each evening before sundown and remained until daylight the next morning. Here they lived throughout the season when malaria was most abundant and a canal near the house was literally swarming with the larvae of *Anopheles*; yet while many of the people in the surrounding regions became ill, the occupants of this house remained perfectly healthy. *Anopheles* mosquitoes which had bitten a malarial patient in Rome were taken to London and there allowed to bite the son of Dr. Patrick Manson. Though he had not previously had the disease, he became ill in due time, and a microscopic examination of his blood showed that the parasites were present in large numbers.

In the summer of 1900 Grassi, an Italian observer, screened completely ten cottages at St. Nicolo, Varco and Albanella in the Plain of Capaccio, Italy. A hundred and four persons, only eleven of whom had previously escaped malaria, were asked to

live in these cottages. Here they lived during the entire malarial season, from June 25th to October 15th, and only five developed symptoms of malaria, though no quinine was taken. The exceptions were light cases ascribed to relapses in persons who had malaria the season before. Of 415 other persons, not protected by screens, in the same neighborhood, every one contracted the disease.

Man, and mosquitoes belonging to the genus *Anopheles*, then, are essential hosts of the malarial parasite; no other hosts are known, and while it is possible that some other may be discovered, it is thought that fully 99 per cent. of the cases of malaria are transmitted to man by *Anopheles*.*

Thus it is seen that the mosquito must bite twice in order to transmit the disease from one person to another. It must also be noted that the mosquito is not simply a mechanical carrier, but absolutely essential to the completion of the life circle of the malarial parasite. Moreover, a period of at least twelve days must elapse between the bite with which the disease is imbibed and the bite which transmits it.

Exactly analogous is the development of an allied parasite (*Proteosoma*) which causes malaria in sparrows and crows, except that the parasite of the birds is harbored by certain mosquitoes belonging to the genus *Culex* instead of *Anopheles*. Much work on bird malaria has been done by Dr. Ross in India with the sparrows, and by MacCallum of Johns Hopkins University with the common crow. These researches have been an important aid in working out the similar development of the human malarial parasite.

Malaria in Connecticut.

From the records that can be obtained it seems almost certain that malaria has occurred in sections of Connecticut for nearly 250 years. But it was not generally distributed nor did it assume the nature of an epidemic until after 1860, when it broke out in the southwestern corner and gradually spread over the state; the disbanded soldiers returning to their homes from the Civil War brought it from the South; in 1882 it seemed doubtful if a single town had been exempt. An inter-

* W. N. Berkeley, Proceedings, first Anti-Mosquito Convention, p. 38.

esting paper by Dr. R. W. Griswold of Rocky Hill* reviews this epidemic in an interesting and suggestive manner, and points out how the disease followed the construction of the Valley railroad from Saybrook Junction northward to Hartford. The epidemic afterwards subsided in a large measure, probably through the almost universal administration of quinine, but malaria still exists and occasional cases appear in all parts of the state. It is unfortunate that we have no record of the cases, but the people are so accustomed to taking quinine for relief that they do so often without consulting physicians. Then too the term "malaria," like charity, covers a multitude of sins and is doubtless applied to many troubles of a different nature. Through the kindness of the Secretary of the State Board of Health I am able to present a record of the deaths from malarial diseases in Connecticut for the past decade.

DEATHS FROM MALARIAL DISEASES IN CONNECTICUT, 1894-1903.

	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	Total.
Intermittent Fever...	16	24	18	17	11	13	53	68	75	38	295
Remittent Fever.....*	28	10	28	27	18	19	24	23	6	7	190
Malarial Cachexia.....								3			3
Pernicious or Conges- tive Fever.....	6	13	11	16	13	15	8				82
Other Malarial Dis- orders.....	65	69	113	67	82	80	37				503
Total (all Malarial Disorders).....	105	116	172	127	124	127	104	94	81	45	1,073

It is reasonably certain that the figures of mortality from these diseases can be greatly reduced in the next decade,—as well as the prevalence of illness from malaria,—if we can abolish the chief breeding places of mosquitoes. Of course we can hardly hope to abolish all mosquito breeding places during the coming year or during the next five years. Education is an important factor in the solution of this problem as it is in the solution of the tuberculosis problem or in fact any similar problem. There is still much ignorance regarding the habits and life histories of mosquitoes, and missionary work must be done before the owners of land will take proper and sanitary care of it.

* Report of Connecticut State Board of Health for 1885.

Yellow Fever.

As early as 1881 Dr. Charles Finlay of Habana noticed a correspondence between the abundance of mosquitoes and of yellow fever. When the island of Cuba was occupied by American troops during the Spanish war and just after the method of transmission of malaria had been established, Surgeon-General Sternberg appointed an investigating commission of army surgeons, composed of Messrs. Reed, Lazear, Carroll and Agramonte, to investigate the yellow fever from the mosquito standpoint. In 1900 these investigations were conducted at Habana and eleven non-immune individuals were inoculated with the disease by the bites of a species of mosquito known to entomologists as *Stegomyia fasciata*. Two positive cases resulted and in one of these all other possible sources of infection had been excluded. Even at this time the cause of the disease was not definitely known, though thought to be a bacterial or plant germ, *Bacillus icteroides*. The researches of the commission, however, showed (1) that this *Bacillus* was not the cause of the disease, but only a secondary invader when present; and (2) that the mosquito served as intermediate host for the parasite of yellow fever.* During the investigation Drs. Lazear and Carroll both contracted the disease. Dr. Lazear died—a martyr to the cause of truth and science and public health—no less a hero than many who have laid down their lives upon the field of battle. Dr. Carroll recovered and the experimental work was later continued. A small house was built and effectually screened against the entrance of all mosquitoes. A circulation of air was also prevented and all sunlight excluded. A temperature of 76.20° F. with a moist air was maintained for sixty-three days—just the conditions favorable to the spread of bacterial diseases. Moreover, clothes, blankets and bedding which had been used by yellow fever patients, and not cleansed were put into the building and used by the inmates. Seven non-immunes were kept in this house, two or three sleeping in one room with the contaminated bed-clothing, for about twenty nights, then shifts were made and other subjects placed under the same conditions. All seven were released from quarantine in excellent health at the end of sixty-three days, not a single case of

* L. O. Howard, Mosquitoes, page 124.

yellow fever appearing. Formerly, contaminated clothing, bedding, etc., were regarded as a dangerous source of infection and were usually burned.

Another similar building was erected by these investigators and was divided into two large rooms, one admitting air and sunlight freely and containing the mosquitoes which had previously bitten yellow fever patients. In this room six out of seven persons bitten came down with yellow fever. From the other room mosquitoes were excluded and the occupants remained in perfect health. These tests still more strongly confirmed previous experiments implicating the mosquito in transmitting yellow fever, and acting on this knowledge General Wood issued orders requiring the use of mosquito bars at the barracks and for the destruction of mosquito larvae in the breeding pools by the use of petroleum. This work, in charge of Col. Gorgas, was carried out thoroughly, and continued until Habana is now a comparatively healthy city. Not a single endemic case of yellow fever has occurred there since September 28, 1901. Patients are often brought to the city from other places, but these are at once screened from mosquitoes, and the fever is not transmitted to others. Mosquito extermination has everywhere been practiced—fumigating buildings with tobacco or sulphur to kill the adults, and draining and filling the pools or applying oil to kill the larvae or wrigglers. Of 26,000 of these mosquito breeding places within the city limits in March, 1901, only 300 remained in January, 1902.* Moreover, the number of deaths from malaria in Habana was greatly reduced from 325 in 1900, to 151 in 1901, 77 in 1902, and 45 up to the first of November, 1903. These efforts at Habana constitute the best demonstration that we have of the efficiency of practical work in mosquito extermination to prevent the spread of human diseases.

But when this work was begun the cause of yellow fever had not been discovered. In 1902 another party was sent out by Surgeon-General Wyman to investigate yellow fever at Vera Cruz, Mexico. This party worked for six months, with the result that a protozoan parasite was found in the bodies of the yellow fever mosquito *Stegomyia fasciata*. This organism is

* W. C. Gorgas, A Few General Directions with Regard to Destroying Mosquitoes; Government Printing Office, Washington, D. C., 1904.

not far removed from the malarial parasite and was thought to be the cause of the disease and therefore named *Myxococcidium stegomyiae*.^{*} Later researches, however, have disproved these conclusions, and Surgeon-General Wyman states in a letter that the causative germ of yellow fever still remains undiscovered.

In 1794 there was an outbreak of yellow fever here in Connecticut with something like 64 deaths occurring out of 160 cases in New Haven. There were also cases in Middletown. A ship had previously arrived from the West Indies and in all probability some mosquitoes were brought to Connecticut in such a way that they could not escape until the boat landed at New Haven.

A third disease which occurs in the East and West Indies, and which is called filariasis or elephantiasis has been found by Dr. Manson to be transmitted by mosquitoes. We have related these investigations and discoveries to show that the agency of mosquitoes in the transmission of disease has been abundantly proved.

WHAT MOSQUITOES ARE.

Mosquitoes belong to the same group of insects as the flies (order *Diptera*). These insects have two wings in the adult stage, with mouthparts fitted for sucking. Mosquitoes have the mouthparts formed into a long and slender proboscis. We can readily distinguish mosquitoes from other flies by the scales on their wings. There is usually a fringe of scales around the margin and along each of the veins, as is shown in figure 12, and on plate XIV, b. Most other flies do not have these scales.

LIFE OF A MOSQUITO.

Like most other kinds of insects, a mosquito has a life cycle made up of four distinct stages, namely: egg, larva or wriggler, pupa, adult or winged mosquito. The second and third stages are passed in the water and cannot exist elsewhere. During the warm summer weather only about one week is required for a mosquito to develop from the egg to the adult state. In cold weather a much longer period is necessary. The eggs of some species, like the rain-barrel mosquito, float

^{*} Bulletin 13, Yellow Fever Institute, Treasury Department, Public Health and Hospital Service. Washington, D. C. 1903.

on the surface of the water where they are deposited in raft-like masses. (Fig. 11.) The eggs of some others, like the salt marsh mosquito, are laid at the edge of the water or in the soft mud; these are not collected in masses and do not float. Eggs of the malarial mosquito float singly upon the surface of the water. The eggs of all species hatch in a few hours and the young larvae or wrigglers feed in the water on minute particles of vegetable matter. Each larva goes to the surface every few



FIG. 11.—Eggs and young larvae of the house or rain barrel mosquito, *Culex pipiens* Linn. All enlarged. (After Howard, Bulletin 25, Bureau of Entomology, U. S. Department of Agriculture.)

minutes to inhale air through the tube or siphon near the tail. After a few days of feeding the larvae change to pupae, which have a peculiar hunchback appearance. Two or three days later the adult mosquito emerges, using the cast skin as a boat in which to stand until the wings are strong and ready for use. The male mosquito neither sings nor bites. The blood of man or some of the higher animals seems to be a necessary food for egg production. Mosquitoes may live for about five weeks in summer, but they usually die after laying eggs. Some kinds of mosquitoes hide away in cellars, caves and other protected places during the winter, emerging in spring to lay eggs for

the first brood. Certain other kinds pass the winter in the larval state, freezing up in the ice and going on with their development after thawing out in the spring. Still others, including the salt marsh mosquito, hibernate in the egg state, in the soft mud of the marshes where they breed. These eggs do not hatch until warm weather comes and until there is an abundance of water in which they can pass their larval and pupal existence. We placed jars of wrigglers in one Hartford and three New Haven store windows, so that persons passing on the sidewalk could see them and watch their development from day to day. One of these jars with label is shown on plate XIII, a.

As a rule mosquitoes do not fly very far from the water where they are reared. *Anopheles*, the species which carry malaria, may fly about one mile. Two species of salt marsh mosquitoes have the habit of migrating inland for thirty or forty miles. The common house or rain-barrel mosquito, as well as most of the other species, are usually hatched and grow in the vicinity where they are found.

NATURAL ENEMIES OF MOSQUITOES.

The most important agents in preventing mosquito breeding, in deep pools, are fishes. Any kinds that take animal food will probably eat mosquito larvae; but the most important are those which feed near the surface like "minnows" or "killies," which belong to the genera *Fundulus* and *Gambusia*. These are usually found in the streams, tide ditches and many of the permanent pools, and can easily be introduced into any permanent body of water where they do not occur naturally.

In many shallow pools not inhabited by fishes we find the larvae of certain aquatic insects that devour large numbers of wrigglers. The adults of certain water beetles, known as "whirligig" beetles, eat many wrigglers each day if they can get them. The larvae of the larger aquatic beetles like *Dytiscus* and *Hydrophilus* eat wrigglers also. One of these (*Hydrophilus obtusatus* Say) in captivity devoured one hundred *C. sollicitans* larvae in about a week. Dragon flies (order *Odonata*) are useful in two ways; their larvae feed upon wrigglers in the water and the adults catch mosquitoes in the air and devour them. It will also be noted by reference to page 306 of

this report that shrimps devour small numbers of mosquito larvae.

A small round worm (*Agamomermis culicis* Stiles) is parasitic in the intestinal tract of the salt marsh mosquito *C. sollicitans*. This parasite was so abundant in New Jersey in 1903 that 80 per cent. of the mosquitoes examined were infested. The abdomen of the female is filled by the parasite, leaving no room for the development of eggs. This parasite has not yet been observed in Connecticut.

LIST OF SPECIES OF MOSQUITOES FOUND IN CONNECTICUT.

So far 22 species have been found in the state. A brief reference to the habits and breeding places of each is given in the following list.

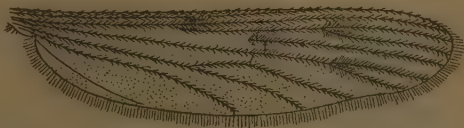


FIG. 12.—Wing of *Anopheles maculipennis* Meig. Enlarged. (After Smith, Report on New Jersey Mosquitoes.)

Anopheles maculipennis Meig.—The real malarial mosquito, which has been demonstrated to be an essential host of the malarial parasite. It probably occurs all over the state, breeding chiefly in fresh water. Compared with other species of mosquitoes it is not very abundant. A wing is shown in figure 12.

Anopheles punctipennis Say.—Seems to be more abundant than *A. maculipennis*, and breeds in similar places. It is a striking species with spotted wings, and more conspicuous than *A. maculipennis*. Probably found all over the state. This species is not known to carry malaria and experiments have been recorded showing that it failed to do so in forty-eight cases under apparently favorable conditions. Shown in figure 13.

While the species of *Anopheles* will breed in any water where *Culex* breeds, the breeding is usually rather scattered and is common along the grassy and ragged edges of streams where the larvae are protected from their natural enemies. The eggs are laid singly and float upon the water, each being cigar-shaped

and provided with air cavities (see figure 14); the air cavities distinguish them from those *Culex* eggs which are also laid singly.

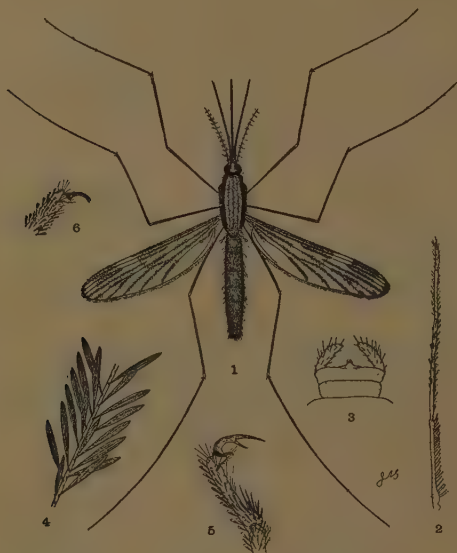


FIG. 13.—*Anopheles punctipennis* Say: 1. adult female: 2. palpus: 3. genitalia: 4. part of wing vein showing scales: 5. anterior and 6. middle claws of male. All enlarged. (After Smith, Report on New Jersey Mosquitoes.)



FIG. 14.—Eggs of the malarial mosquito, *Anopheles maculipennis*. Enlarged. (After Howard, Bulletin 25, Bureau of Entomology, U. S. Department of Agriculture.)

The young larvae appear from twenty-four to forty-eight hours after the eggs are laid, and there is much color variation in all sizes of the larvae. They are usually spotted with white when young and become more or less uniform and dark grey when near the pupa stage. It is not unusual, however, to find them light or dark green or even black, resembling bits of grass or debris. This seems to be a protective resemblance through which they are able to escape their natural enemies.

Throughout their larva existence they pass most of the time at the surface of the water, where they lie horizontally and quiet, thus increasing their resemblance to bits of debris. The larva is not provided with a long air tube as in *Culex*, and *Culex*



FIG. 15.—Larva of *Anopheles*; dorsal view. Greatly enlarged. (After Felt, Culicidae of New York State.)

larvae hold their heads downward when at the surface of the water for air. Both *Culex* and *Anopheles* larvae are shown in figure 21.

The malarial mosquito flies at night and seldom more than a mile from its breeding place, usually being found near it. The breeding season begins in May and continues into November, the species being much more abundant during the latter part of the summer. *Anopheles* lives through the winter in a dormant condition in cellars, caves, and other secluded places, sometimes appearing even in midwinter. The two species of *Anopheles* cannot easily be distinguished in the larval form, and of the adults reared from the larvae collected in the state, a majority were *A. punctipennis*, though the other species was also found.

Culex pipiens Linn.—This is the common rain-barrel or house mosquito that breeds as if by preference in the vicinity of houses, or wherever water stands that is free from mosquito enemies. It makes no difference how dirty the water is. The species deserves its name of house mosquito for it invades houses almost exclusively. Rain-water barrels and receptacles of all kinds are favorite breeding places of this species, but pools of foul or muddy water are often selected. In Hartford on

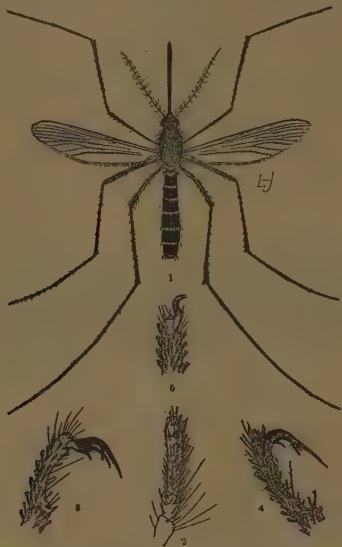


FIG. 16.—The house or rain-barrel mosquito, *Culex pipiens* Linn: 1. adult female; 2. palpus; 3. anterior, 4. middle, 5. posterior claws of male. All enlarged. (After Smith, Report on New Jersey Mosquitoes.)

October 24th we found the highly colored water of a pool close beside a large heap of composted stable manure, to be fairly alive with the larvae of this species. To show how rapidly it breeds, Dr. Luggar of Minnesota counted 17,259 eggs, larvae and pupae of this species in a rain-water barrel in July. These were all destroyed and the barrel again filled with water. Sixteen days later there were 19,110 eggs, larvae and pupae in the same barrel."

The eggs are laid in raft-shaped masses, containing from 200 to 400 eggs, placed side by side, the end of each touching the

water. They hatch in about ten days, the larvae dropping from the lower end directly into the water, where they immediately begin to wriggle about. The larva has a large head and thorax, and a long air tube near the posterior end of the body, which it extrudes from the surface of the water in breathing, during which time it can be seen with head downward. It descends to the bottom, where it feeds upon the spores of algae or other



FIG. 17.—The salt marsh mosquito, *Culex sollicitans* Walk.: 1. adult female: 2. palpus: 3. anterior, 4. median and 5. posterior claws of male. All enlarged. (After Smith, Report on New Jersey Mosquitoes.)

vegetable matter. In about seven days in warm weather the larva becomes full-size and changes to a peculiar looking hunch-backed wriggler, the pupa, from which, after about two days, the adult emerges. This species is usually the most abundant and troublesome within doors. Some of the adults hide away in buildings and pass the winter, emerging in the spring to lay their eggs. The eggs and young larvae of this species are shown in figure 11 and the adult in figure 16.

Culex pipiens flies only a short distance from its breeding place, and is therefore easily controlled, but as it breeds every-

where, concerted action is necessary. Other inland species are only of local importance and are mentioned on page 278.

Culex sollicitans Walk.—Is the most common species of the salt marsh and remarkable for its migratory habits, sometimes going thirty miles. It breeds abundantly in certain pools in the marsh during the last half of summer. The species can be easily distinguished by the conspicuous white-banded legs and beak and is shown in figure 17.

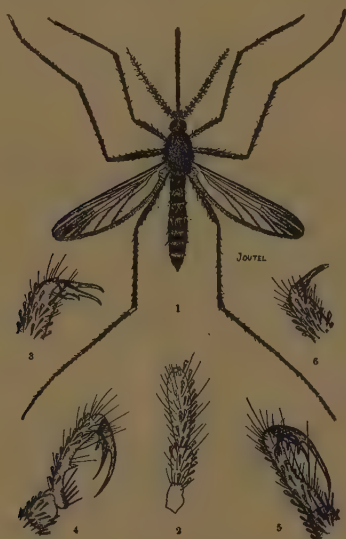


FIG. 18.—The brown salt marsh mosquito, *Culex cantator* Coq.: 1. adult female; 2. palpus; 3. anterior claw of same; 4. 5. 6. anterior, median and posterior claws of male. All enlarged. (After Smith, Report on New Jersey Mosquitoes.)

Culex cantator Coq.—Is called the brown salt marsh mosquito and is the common species on the Connecticut marshes in May and June. Like *C. sollicitans* it migrates inland long distances, and both species are very troublesome pests near the coast. Shown in figure 18.

Culex sylvestris Theo.—Breeds in fresh swamps and in many permanent and temporary pools near the swamps. In some localities it visits the house and becomes a nuisance.

Culex cantans Meig.—Does not fly far from its breeding place in or near woodlands and is too rare to be important.

Culex canadensis Theo.—Is a woodland species, most common early in spring. It is not troublesome except where dwellings are located near the breeding places.

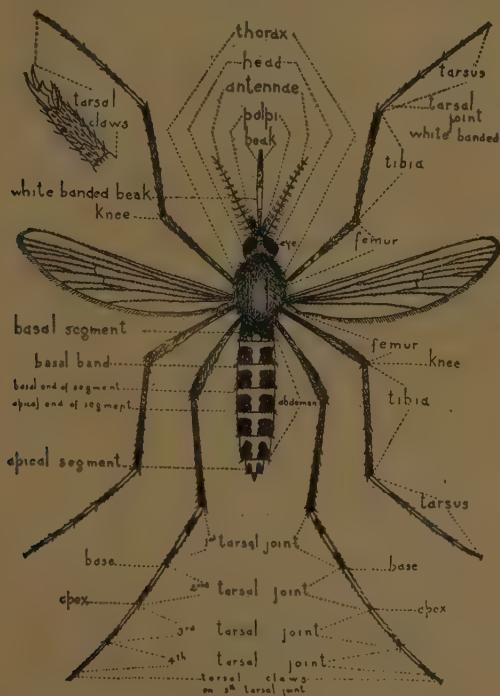


FIG. 19.—Adult mosquito and names of its parts, which are used in classification. (After Smith, Report on New Jersey Mosquitoes.)

Culex atropalpus Coq.—Breeds along streams in depressions of rock, etc. We found it only in ledges near the Sound where depressions had become filled with rain water. It is apparently only a local nuisance.

Culex trivittatus Coq. and *triseriatus* Say.—Are comparatively rare woodland species; any trouble they may give will be strictly local.

Culex pretans Grossbeck.—Has formerly been regarded as a comparatively rare woodland species. At Hartford we found it breeding by the million in wooded pools at south meadows, from which it spread into the adjoining portion of the city, becoming the most troublesome mosquito. (See figure 22 and plate XII.)

Culex territans Walk.—Is a pure water mosquito, comparatively rare and occurring in springs. It may become a nuisance.

Culex curriei Coq.—A fresh water species. A single specimen was taken at New Haven—the first record for the species east of Nebraska, but it has since been found in New York.

Culex aurifer Coq.—Breeds in fresh water. Only a few specimens were found during the season.

Culex brittoni Felt.—A single specimen found at Branford proved to be a new species and was described recently by Dr. Felt.

Aedes fuscus O. S.—A fresh water species. Three adults taken at New Haven and Southington.

Sayomyia americana Johan.—The members of this genus do not bite like the mosquitoes of the genera *Culex* and *Anopheles*. The larvae were found breeding in pools in an abandoned stone quarry at Stony Creek.

KEY TO IDENTIFY THE SPECIES OF MOSQUITOES FOUND IN CONNECTICUT.

A. Proboscis short, not formed for piercing: CORETHRINAE.

a. First tarsal segment longer than the following segment; species small; antennae with hairs in whorls: *Sayomyia*.

(But one species, *S. americana* Johans., has been found in Connecticut.)

AA. Proboscis long, formed for piercing.

a. Palpi long in both sexes; wings usually spotted:

ANOPHELINAE.

b. Species with yellowish white marginal spot near the apical fourth of the wing: (*Anopheles*) *punctipennis*.

bb. Without yellowish white spot as above:

maculipennis.

aa. Palpi short in both sexes: AEDEOMYINAE (*Aedes*) *fuscus*

aaa. Palpi short in female; wings unspotted: CULICINAE.

b. Size large (length about 11 mm.); legs thickly covered with nearly erect scales: (*Psorophora*) *ciliata*.

bb. Size smaller (4.5-7 mm.): *Culex*.

- B. Joints of the tarsi and segments of abdomen banded at the base.
- a. Beak with a more or less distinct white band.
 - b. Upper surface of abdomen with a longitudinal whitish stripe.
White band at middle of beak; sides of thorax whitish beneath a blackish edge: *sollicitans*.
 - bb. Abdomen without longitudinal stripe.
 - c. Hind tibia with a light band near the tip.
A large scaly brown mosquito: *perturbans*.
 - cc. Hind tibia without markings: *taeniorhynchus*.
 - aa. Beak without band.
 - b. Segments of abdomen white banded at base.
 - c. Claws toothed.*
 - d. Bands of tarsi broad. 6-6.5 mm.; light brown with the yellow bands of the abdomen only slightly notched: *cantans*.
 - dd. Bands of tarsi narrow. Small dark species with white bands of abdomen nearly divided in the middle: *sylvestris*.
 - cc. Posterior claws simple; tarsal bands narrow. Otherwise resembles *cantans*: *cantator*.
 - ccc. All claws simple; wing fringe uneven: *brittoni*.
- BB. Joints of the tarsi banded at both ends; last joint white.
- a. Bands of the tarsal joints broad; thorax unmarked. A good sized brown mosquito: *canadensis*.
 - aa. Bands of tarsal joints narrower; thorax with grayish scales and a dark central line. Slightly smaller and darker than the preceding species:† *atropalpus*.
 - b. Abdomen yellowish white with a pair of black scale patches on segments 2-5 inclusive: *curriei*.
- BBB. Joints of the tarsi not banded.
- a. Abdomen not banded.
 - b. Thorax with a central brown stripe between two whitish stripes: *trivittatus*.
 - c. Thorax brown on top; sides covered with golden scales: *aurifer*.
 - d. Thorax dark brown on top; sides covered with whitish scales: *triseriatus*.
 - aa. Abdomen with segments banded at base.
 - b. 4.5-6 mm. (about $\frac{3}{16}$ - $\frac{1}{4}$ in.). Bands of abdomen narrow: *pipiens*.

* This character is sometimes necessary to distinguish *C. sylvestris* and *C. cantator*. It also serves to distinguish rubbed specimens of *C. cantans* and *C. cantator*.

† The petiole of the first sub-marginal cell in *C. canadensis* is about two-thirds the length of the cell; while in *C. atropalpus* the petiole is about one-half the length of the cell.

BBB. Joints of the tarsi not banded.

c. Similar to *pipiens*; slightly darker; legs longer and more slender: *salinarius*.*

d. Thorax yellowish with a darker central stripe; a medium sized darkish species: *pretans*.

aaa. Abdomen with segments banded at apex.

b. A small dark species: *territans*.

KEY TO LARVAE.

A. Larva without air tube on last abdominal segment.

b. Larva transparent or nearly so; last segment with hooks; no spiracles apparent: *Sayomyia*.

(Only *S. americana* has been taken in Connecticut.)

bb. Larva not transparent.

c. Last abdominal segment with flat dorsal area containing two spiracles; anal segment cylindrical: *Anopheles*.

AA. Air tube long, conspicuous.

b. Larva large, about $\frac{1}{2}$ inch long: (*Psorophora*) *ciliata*.

c. Larva small, from $\frac{1}{4}$ – $\frac{3}{8}$ inch long: *Culex*.

d. Air tube 6 or more times as long as broad.

e. Head as wide as thorax: *territans*.

f. Head narrower than thorax: *salinarius*.

dd. Air tube 4–5 times as long as broad: *pipiens*.

ddd. Air tube $3\frac{1}{2}$ times as long as broad.

e. 28–40 spines on air tube; 25–30 comb scales: *aurifer*.

dddd. Air tube $2\frac{1}{2}$ times as long as broad.

e. With 16–24 spines: 36–50 comb scales: *canadensis*.

f. Antennae short; 14–16 spines: 10–15 comb scales: *sylvestris*.

g. Antennae longer with slight swelling at base; 16–24 spines: 26–50 comb scales: *cantans*.

h. Antennae shorter than preceding without swelling at base. Spines and scales as above: *cantator*.

i. Antennae tuft only a single hair: comb scales about 46 in 5 rows. Several spines on air tube widely separated from the others: *atropalpus*.

j. spines on air tube in a continuous row, distal ones not widely separated.

k. 12 comb scales, arranged in an irregular double row: each divided digitately: *triseriatus*.

l. 14–22 comb scales, elliptical, each with a terminal spine: *trivittatus*.

* Salt marsh species.

AA. Air tube long, conspicuous.

m. 16-20 spines on air tube; 25-30 comb scales;
thorax broader than long with sides angu-
lated: *pretans*.

dddd. Air tube not more than twice as long as broad.

e. Spines dentate on both sides: 16-24 scales
in comb: head maculate: *taeniorynchus*.

f. About 14 spines dentate on one side only:
28-40 comb scales: head generally immacu-
late: *sollicitans*.

The larvae of *Aedes fuscus* and *Culex curriei* have not been observed in Connecticut, while that of *C. brittoni* is unknown.

OTHER SPECIES PROBABLY OCCURRING IN CONNECTICUT.

The following species have been found in New York or New Jersey, and most of them will, doubtless, be taken in Connecticut, though not yet collected here.

Culex discolor Coq.—A species with banded tarsi and spotted wings, slightly resembling *Anopheles*.

Culex jamacensis Theo.—A large blackish species with a white band near the tip of the femur. Somewhat resembles *sollicitans*.

Culex squamiger Coq.—A very large mosquito with tarsal joints white banded at base; sides of thorax and abdominal bands white.

Culex signifer Coq.—A small dark form with fine bluish lines on top of thorax; wings somewhat mottled.

Culex serratus Theo.—A golden brown species with a broad central sharply defined white stripe on top of thorax.

Culex dupreei Coq.—A very small blackish species with a white central diffused stripe on top of thorax.

Culex restuans Theo.—Has a pair of white dots on top of thorax in front of a shaped white mark. Narrow bands at ends of hind tarsal joints.

Culex melanurus Coq.—A dark brown species of moderate size; legs, thorax and abdomen unbanded.

HOW TO DISTINGUISH MALARIAL FROM NON-MALARIAL MOSQUITOES.

Anopheles, the malarial-bearing mosquito, may be distinguished from *Culex*, the non-malarial mosquito, by the following characteristics:

Anopheles.

Larva small, with short breathing tube, and lying horizontally at the surface of the water.

Adult with spotted wings; beak and body almost in a straight line, nearly perpendicular to the surface on which the mosquito stands. Palpi nearly as long as beak in both sexes.

10. *Culex*.

Larva larger than *Anopheles* with large head hanging downward in the water, and longer breathing tube. (See figure 21.)

Adult usually with wings unspotted; beak forms an angle with the axis of the body; body nearly parallel to the surface on which the mosquito stands. Palpi short in female.

BREEDING PLACES AND HOW TO LOCATE THEM.

Mosquitoes can only be eradicated or greatly reduced in number by destroying their breeding places so that the eggs

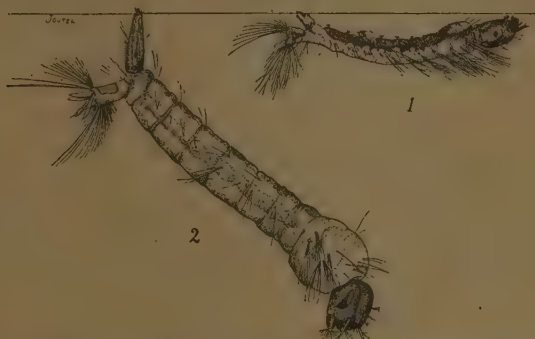


FIG. 21.—Larvae of *Culex* and *Anopheles*, showing the characteristic position of each at the surface of the water. 1. *Anopheles*: 2. *Culex cantator*.

cannot hatch, or by killing them while in the immature condition in the pools where they are breeding. It is of the first importance therefore to find where the different species breed.

Mosquitoes do not breed in grass and weeds, as many persons suppose, but only feed and rest there during the day, flying out when disturbed. They breed only in water, usually in stagnant pools, and receptacles such as rain-water barrels, kettles, tin cans and bottles which have been allowed to remain where they will fill with water. They do not breed in running streams, but often such streams have ragged edges forming little pools where the water stagnates, and in such places mosquitoes will breed. Many of the worst breeding places are caused by the building of roads across marshes, cutting off the natural drainage and leaving depressions where water collects and stag-

nates. Most species of mosquitoes breed only in fresh water, but a few kinds breed in the salt and brackish water of marshes along the coast. *Anopheles*, the malarial mosquito, will breed in almost any water sustaining *Culex*. Many pools are stocked with fishes or aquatic insects that devour the larvae and so prevent the breeding of mosquitoes. The use of oil on the surface of such pools may do more harm than good, because it may kill the natural enemies of mosquitoes. Ponds filled with green slime or duck-weed are usually not serious breeding places of mosquitoes. Serious breeding places are comparatively few when the total number of pools is taken into account. This simplifies the problem of mosquito control, as all efforts can be concentrated against these few serious breeding places.

To determine where mosquitoes breed, it is necessary to examine the entire area and test all pools for wrigglers. For this purpose a kitchen ladle of agate or some similar ware with bowl lined with white enamel is the best thing that we have found. (See plate XVI, a.) Water is dipped up in the ladle from different parts of the pool and each time examined to see if it contains eggs, larvae, or pupae. These, being dark, show up nicely against the white background. In some pools where larvae are abundant any number from 10 to 100 larvae may be taken at each dipping. In order to be perfectly sure of the status of pools several examinations should be made at different times during the season, including tests early and late and during mid-summer and in periods of scanty and abundant rainfall. The infested pools should be charted on a map of the region, and field notes of each examination should be made and kept for reference, as this is a necessary preliminary to any form of exterminative measures. It is also well to preserve larvae and pupae and also to rear adults if a study of the species is contemplated. In any case the person making the examination should be familiar with mosquito life and be able to distinguish the malarial from the non-malarial kinds.

A MOSQUITO SURVEY OF CONNECTICUT.

This survey was commenced in the spring of 1904 to determine what species inhabit the state and where are their chief breeding places. A systematic examination was made of the coast region from New York to Rhode Island, and a few inland

regions which were brought to our attention were also examined. The junior author, Mr. Viereck, worked in the field all summer, testing pools, mapping breeding places, collecting specimens and making such field notes as would be likely to prove useful in further study of the mosquitoes or in the practical work of controlling them. The breeding areas were marked on maps and a copy of the local map with descriptive notes and recommendations for treatment was sent to the health officer of each of the shore towns. Maps of the Hartford and New Haven regions are reproduced in this report.

Many larvae were collected and preserved for future study, and adults were also reared from each lot. The more important results of the investigation appear in the following pages.

WEATHER CONDITIONS.

Since mosquitoes must have water in which to breed and some species prefer stagnant rain water to other water, the amount of rainfall is of the greatest importance. The salt marsh mosquitoes depend to a great extent and at times entirely on rain-water pools for breeding places; consequently their broods bear a direct relation to periods of rainfall.

April.—The largest rainfall for any one day was 1.68 in., on the 1st. Less than 1 in. fell on any other day; the total for the month was 6.64 in. The lowest temperature for the month was 24°, the highest 77°. Pools existed in depressions that became dry during May and remained so during the greater part of the summer.

May.—During the first part of May, when the mosquito survey was started, the spring pools contained larvae of *Culex pipiens*, the rain-barrel mosquito and *Culex canadensis*, a woodland species. The largest rainfall, 1.07 in., was on the 30th. Rainfall on other days was .80 in. or less. The total for the month was 2.94 in. The lowest temperature was 39°, the highest 85°.

June.—On the 9th .70 in. of rain fell; on other days .44 in. or less. The total was 2.46 in. The temperature ranged from 45° to 93°.

July.—On the 18th there was a heavy rainfall of .52 in.; on another day .50 in., on all other days, .23 in. or less. Total, 2.08 in. Temperature, 51° to 93°.

August.—On the 20th there was a heavy rainfall of 3.11 in.; on the 10th a fall of 1.74 in., on all other days .62 in., on the 2d, of less. Total, 6.27 in. Temperature, 50° to 84°.

This summary of weather conditions indicates what a poor chance the mosquitoes, fortunately, had to breed during the past season. The total rainfall before June afforded breeding facilities of a varied character in woodland and on the marsh; conditions which did not again occur during the season. In June the light rains afforded only sparse breeding. During July breeding occurred chiefly in pools caused by an extra high or perigee tide. In August, breeding was generally started by the heavy rain of the 2d, which, however, amounted to only .62 in. The brood started at this time did not mature in all places. On the 10th the heavy rain started another brood which matured and emerged about the 19th. On September 2d some mature larvae were found in a pool which was almost dry, and others dead and dry were observed in depressions from which all the water had evaporated. These observations were made on salt marsh mosquitoes. In the inland regions very few fresh water mosquitoes were found outside of the more permanent streams and pools after the temporary pools had become dry.

A. THE INLAND REGION.

In the inland region mosquitoes chiefly breed in small natural or artificial pools of rain-water, in swamps, along the ragged grassy edges of streams, and in receptacles such as rain-water barrels, kettles, tin cans, bottles, etc. Breeding is nowhere general over so large an area as on the salt marshes. Moreover, the chief kinds of mosquitoes are not the same species that are the most annoying near the coast.

CHIEF INLAND SPECIES OF MOSQUITOES.

Anopheles, the malarial mosquito, also called "dapple wings," must be considered the most important because of its agency in the transmission of malaria. In point of number, fortunately, it ranks far below the rain-barrel or house mosquito, *Culex pipiens*, which is the most abundant of all inland species. *C. pretans* Gross. was abundant at Hartford in May. All other fresh water species are only rarely abundant and breed near the place where they are found. *C. sollicitans* and *C. cantator*

are salt marsh species, but on account of their migratory habits may be found inland throughout the southern half of the state.

HARTFORD.

Hartford has the usual inland mosquito problem augmented by meadow land along the Connecticut River, where in large depressions water collects and mosquitoes breed abundantly.



FIG. 22.—*Culex pretans* Gross: 1. adult female: 2. anterior, 3. middle, 4. posterior claws of male. All enlarged. (After Smith, Report on New Jersey Mosquitoes.)

The ragged edges of the streams in and about this city are the chief source of malarial mosquitoes. Nearly every test made along the edges of the Hartford streams in late summer revealed larvae of the malarial mosquito. In May the most common mosquito in Hartford was *Culex pretans*, a species that breeds in woodland pools. It was present in great numbers in the spring and caused considerable annoyance in the southeastern portion of the city. When the Common Council voted an appropriation to be spent by the Board of Health in oiling the pools, we made an examination of the suspicious areas in the

vicinity of Hartford in order to locate the real breeding places and submitted the following report to the Board of Health.

"We hereby submit a preliminary report on the location of the mosquito breeding places in the vicinity of Hartford. A close examination has been made of the lowland west of the Connecticut river, including the south meadow for a distance of two and one-half miles from the City Hall, and of the north meadow for a similar distance. The examinations were made on May 17, 18 and 20, and revealed the worst breeding pools within this area, and probably in the vicinity of Hartford. It should be understood that in these examinations all pools were tested to determine whether mosquitoes were breeding in them or not. Also that no instruments were used to ascertain levels—an important work to be done by the engineer before any extensive treatment by drainage can be carried out.

South Meadows.

Here the low land naturally favors mosquito breeding, but the worst breeding pools have been caused by the interception of the natural drainage by the building of roads, especially the Valley Division of the New York, New Haven and Hartford railroad. The principal breeding places are shown on the accompanying map. A small marsh area on the Colt estate just north of Wawarme ave. (6) breeds mosquitoes to some extent and has already been sprayed with oil this season. But the oil treatment cannot be very effective on a grass-covered marsh, and this area should be either filled or drained. The large pools are stocked with fish and are probably safe. The breeding pools contiguous to and just south of Wawarme ave. (14) yield, no doubt, the mosquitoes most noticed by the residents of the city. These pools are not extensive and could probably be filled completely or nearly so at small expense with the ashes and other material that has been dumped alongside the pools from the avenue. The marsh south of Wawarme ave. is soggy and has water standing almost everywhere, still the breeding is confined to the edge nearest the line of trees (21), as indicated on the map. Below this somewhat enclosed area the soggy marsh land extends to Meadow Road. It is imperfectly drained by the creek (7) shown on the map. The stream is choked, and actually breeds mosquitoes, though not a chronic breeder. This creek should be kept open through the entire meadow. This marsh area will need to be drained with ditches or else the water will need to be concentrated into a pond and stocked with fish. Drainage will no doubt prove to be the most feasible and satisfactory solution of the problem here. Along Meadow Road between Wethersfield ave. and the Valley Division of the New York, New Haven and Hartford railroad (8), drainage will secure the best results because the creek at this place has a good flow and lies lower than the adjacent area.

The pools along the railroad (9) can be treated in three ways, either of which should prove effective,—(1) by drainage through ditches deep enough to do the work at all times, emptying into the creek at Meadow



Road and the Connecticut River at Wawarme ave.—(2) by filling—perhaps the most expensive method in this place—(3) by removing the trees that shade the water and converting all the pools into fish stocked ponds. The breeding pool near Wawarme ave. is shown on plate XII.

At 15 and 16 (see map) are pools that would be drained if the ditches that connect them with the cove were made and kept deep enough to do the work. At 17 (see map) is a serious breeding area among trees and bushes extending over more than an acre of land. The remedy here will consist in the removal of the trees and bushes so that this part of the lake will be open like the other portion where mosquitoes do not breed. At 18 is another place that requires clearing. Clearing away trees and bushes is advocated here because the very abundant mosquito is a woodland species that develops in the shade of the wood: it will, therefore, disappear naturally when the conditions are changed. If the trees and bushes are removed, fish will doubtless prevent the breeding of other kinds of mosquitoes in this area.

North Meadow.

The north meadow is apparently higher than the south meadow, and does not present chronic breeding pools such as are found in the latter area. Along the river the ground is dry and has a good drainage, giving excellent opportunities for farming. Along the New York, New Haven and Hartford railroad the ground is low, soggy and full of depressions holding fresh water—a typical fresh-water marsh, the excess of which is drained off by Meadow Creek. Some of the outer edges of this marsh toward the river had a sparse mosquito population in the water-filled depressions, enough to show that this particular area will have to be examined again at some more opportune time (considering that it had rained the day before the examination and that the present brood was fast leaving the water); still on the whole, this area does not look as though it could ever produce as many mosquitoes as the south marsh.

A mile north of City Hall, between the New York, New Haven and Hartford railroad and the river, are some wooded coves that have a similar appearance to the typical breeding places in the south meadow, but to get the true character of these places an examination will have to be made when a brood is forming.

With the successful treatment of the areas enumerated, the really serious part of the mosquito problem for Hartford will have been solved. It is always best, where possible, to destroy the breeding places of mosquitoes in some such manner as we have indicated rather than to merely make them useless for the time being.

Kerosene sprayed upon the surface is at best only a temporary expedient, and needs repeating about every ten days—yet it may be employed effectively to make the breeding pools temporarily safe while the permanent work is being done."

The Park River and tributaries were examined in August. Tests were made at various points from Capitol avenue to the city line. *Anopheles* were found generally along the ragged edges (1, 2, 3, 4, 5), where they were protected from their enemies by the aquatic plants and grasses. To prevent this breeding it will be necessary to clean up the river edges. *Anopheles* were also found breeding along the edge of the stream at No. 11.

On September 12th the breeding areas in Keney Park were examined. These consisted of a series of pond holes and isolated pond holes extending from Hartford north into Windsor. The pond holes were of various types, one containing sphagnum, cat-tails, etc., another button bush, etc., a third mermaid weed, *Proserpinaca*. They were in some cases seven feet deep and most of them were dry. At this time standing water was found only in the pond with sphagnum, where in a pocket with water, a short tubed larva of *Culex* was found. Some of the depressions had been filled, as is related on page 304 of this report, and all will be taken care of in the near future.

South of Keney Park in the water of a large clay pit on the Sage estate, *Anopheles* were found in abundance.

EAST HARTFORD.

In August part of a day was spent in examining that portion of East Hartford adjoining the Connecticut River, from the bridge southward for about one mile. Just south of the bridge (10) in the bank of loose earth, depressions holding water were breeding *Anopheles* and *Culex*. The meadow was comparatively dry and appeared to be higher than the meadow opposite in Hartford. One depression was found that looked like a typical breeder of *Culex pretans*, but it was dry at the time. *Anopheles* breeding in this region will undoubtedly fly into Hartford.

MIDDLETOWN.

At the suggestion of Prof. W. O. Atwater of Wesleyan University, an examination was made of the mosquito breeding conditions in the immediate vicinity of Middletown on June 18th by Messrs. Britton and Viereck in company with Mayor Crittenden. It was reported that mosquitoes had been rather abund-

ant in the northwestern portion of the city, while in the southern and eastern portion they were not troublesome. A fountain at the intersection of Washington and High streets had been suspected, but on making a careful examination no wrigglers could be found in it.

The swamp south of the Air Line division of the New York, New Haven and Hartford railroad just west of the point where the railroad crosses Washington street, is not well drained and the malarial mosquito, *Anopheles*, was found breeding here quite extensively. This area was probably once properly drained, but the ditches have become clogged by deposit and vegetation. Two or three open ditches, properly placed, would do away with the nuisance and the expense would be slight. Sparse breeding of *Anopheles* and *Culex* also occurs in the grassy ditches north of the railroad just west of where it crosses Washington street. A duckweed pool close beside the tracks of the railroad connecting Middletown and Berlin and southeast of the shops where the Keating bicycles were formerly manufactured, is being filled by using it as a public dump. *Culex* was found breeding in this stagnant water. The best treatment for this pool is to let the good work go on and fill it as soon as possible. No other breeding areas worth mentioning were found about Middletown, but perhaps breeding areas occur in some of the adjoining towns or localities which must be examined at another time.

CHESHIRE.

The problem presented at this place is very interesting and warrants the insertion here of an extract from our report sent to the health officer of this town.

On July 8th, the region along both sides of the railroad for about one mile north and one mile south of the railroad station was examined for mosquito breeding places.

On the east side of the railroad, in the canal, *Anopheles* and *Culex* were found all along the ragged edges among the duckweed, from the factory north for about one mile or as far as the tests were made. Refuse injurious to the duckweed empties into the canal from the factory of the Ball and Socket Mfg. Co. Apparently this refuse is not injurious to the fish resembling carp that were seen in the water, both above and

below the factory. No mosquito larvae of any kind were found south of the factory and the edge of the stream here is quite clean, and not ragged with vegetation as it is north of the railroad station.

On the west side of the railroad north of the station is a depression which may become filled with water during a heavy rain and may breed mosquitoes. South of the railroad station, along the swift brook, no indication of mosquito breeding was detected. This stream is probably safe at all times.

To rid Cheshire of malarial mosquitoes it will be necessary to keep clean the margins of the canal and remove the duck weed so that the fish will be able to reach every portion of the stream. If the cause of the breeding (i. e., ragged edges and duckweed) is not removed, the canal will have to be sprayed with kerosene oil once every two weeks if the mosquito pest is to be mitigated.

REMEDIAL TREATMENT FOR INLAND AREAS.

The best treatment is to abolish permanently all breeding places wherever possible. This can often be done at small expense by opening old drains that have become choked or by cutting new ditches to carry off all standing water. Filling small areas is often cheaper than draining. Where neither is practicable on account of the low level or great distance to cut ditches, a portion of the area can be dredged and the remainder either filled with the dredgings or drained into the depression, thus forming a permanent pond which should be well stocked with fish. In other words, the standing water of swamps should either be drained off or else concentrated into fish-stocked ponds.

The banks of all ditches and pools should be kept clean and rather steep and no ragged edges allowed, for these hold water in which mosquitoes can breed out of the reach of fish. Such pools as cannot be treated by either of the methods just described can be sprayed every ten days with kerosene or light fuel oil. The application should be made while the larvae are in the water. Mosquitoes develop in broods, and if the oil is applied just after the adults have emerged it will probably disappear before the next brood of larvae develop. Oil can also be used to good advantage to render breeding pools temporarily safe until the drainage or other permanent work can be carried

out, but the indiscriminate use of oil on pools is not to be recommended.

Very often the sudden appearance of mosquitoes about the house can be traced to water standing on the heads of barrels, in tin cans half-full of rain water, or in half empty bottles. The removal of these things from the premises will often greatly diminish the annoyance. All dwellings should be thoroughly screened wherever mosquitoes are abundant.

Rain-water barrels should always be screened to prevent mosquitoes from laying their eggs; this may be done by fastening a piece of cheese cloth to a hoop large enough to slip over the top of the barrel.

B. THE COAST REGION.

The towns forming the coast of Connecticut are confronted by a mosquito problem essentially different from that of the inland towns, for the salt marsh species breed along the coast and, though not the only kinds occurring there, far exceed all others in point of abundance.

The salt marsh area of the state, equalling 34.79 square miles or 22,264 acres,* is unevenly distributed along the coast, being most extensive between Southport and the Connecticut River. When we consider that fully 50 per cent. of this area has been thoroughly drained for salt hay farming, and that some of the marshes and portions of others are naturally well drained, it will be seen that the problem of making this marsh area proof against mosquito breeding is by no means a discouraging one. A brief description of the marsh territory with our observations covering one season will show what we have to contend with, in an effort to abolish the breeding places of the salt marsh mosquito.

In looking over the coast marshes which are mostly salt, many fresh-water pools and marshes were also examined. The streams of the salt marshes are usually fed by inland lakes, springs, and by surface drainage. These streams change the character of the salt marsh vegetation, which is replaced along their courses by fresh-water plants; also the mosquito fauna is

*D. M. Nesbit, Miscellaneous Special Report No. 7. The Tide Marshes of the United States, U. S. Department of Agriculture, 1884.

modified, salt marsh species being replaced by fresh water or inland species. The latter are usually sparse if present and breed much less rapidly than the salt marsh species. The smaller marshes are often entirely salt, but a large quantity of fresh water in the streams sometimes causes the formation of quite extensive areas of fresh marsh. At the mouth of the Connecticut River there is an excellent example of this influence of the fresh water upon the character of the vegetation. The salt marsh is here confined to the extreme mouth of the river, while immediately within the mouth and up the river the marshes are of the fresh brackish water type, and practically free from the breeding of salt marsh mosquitoes. A large portion of the great Quinnipiac marsh of over 3,600 acres, near New Haven, is in a similar condition.

COAST MOSQUITOES.

The most abundant mosquitoes on the marshes are the salt marsh mosquito, *Culex sollicitans* and *C. cantator*. In New Jersey these species are known to migrate inland for a distance of over thirty miles, but it is not yet evident that they do this in Connecticut. We have found them five miles inland, but our observations are limited owing to pressure of other work. During frequent visits to Hartford throughout the summer and visits to Middletown and Derby we searched for, but did not find these species. Mr. Walden collected insects at Scotland during the last week in July, but found no salt marsh species. The inland migration is undoubtedly checked in Connecticut by the hills near the shore. Large numbers of salt marsh mosquitoes were found in the grass and bushes on Prospect Hill, New Haven, after the emergence of each brood, showing this hill to be a barrier to migration. The most favorable routes for inland migrations are evidently up the Housatonic, Quinnipiac and Connecticut rivers.

In May and June the broods on the salt marshes were comparatively light and *cantator* was present almost to the exclusion of *sollicitans*. As the season advanced however, *cantator* was gradually and almost completely replaced by *sollicitans*. During the season about seven distinct broods were generated, the broods following; almost without exception, the rains. Some light breeding was caused by tide water, and at least one rather

annoying and large brood was started and brought to maturity at Fairfield in depressions filled with tide water and free from fishes. It is not known whether or not these species come into Connecticut from Long Island. It is highly probable that they may do so at times. Certainly the western end of the Connecticut coast region must occasionally receive mosquitoes from New York.

Aside from the two species just mentioned we find *C. taeniorhynchus*, *C. perturbans* and *C. salinarius* on the salt marshes of the coast region. Also some of the fresh-water species, including *Anopheles maculipennis* and *A. punctipennis*, frequently breed in the fresh areas separated from the tide water, around the edges of the marsh. But all of these species fly only short distances and are less troublesome generally than the migratory forms. All, however, may be troublesome locally.

DRAINAGE CONDITIONS OF THE SALT MARSHES.

The marshes vary greatly as to natural drainage and other conditions. Some marshes contain several broad streams affording more than adequate drainage; again we find only a single narrow stream through a large marsh area and the marsh insufficiently drained; or perhaps a stream has been choked with sand or debris and the drainage cut off completely.

Slough holes are shallow or deep depressions or ponds said to be formed by the pressure of large cakes of ice on the soft marsh, thus creating the initial depressions which hold water; during hot weather the water reaches a high temperature and the grass decays. The decayed material is washed away from time to time by the extra high tides and this process going on for years makes deep holes. The deeper ones, however, are constantly filled with water in wet seasons and as fishes are supplied by the extra high tides, these slough holes are free from mosquitoes. In a very dry season, however, even these deep depressions may become dry and the fishes perish. When again filled with rain-water or by an exceptionally high tide each becomes a serious breeding place which must be treated either by ditching or restocking with fishes. The fact that slough holes are formed in this way makes it necessary to inspect all marsh areas annually if we would prevent mosquito breeding absolutely.

In salt marshes bare depressions lined with a felt-like covering occur, formed by the growth of algae. In these areas mosquitoes do not usually breed, but may breed there if their favorite pools in the black and spike grass depressions are drained. This appeared at Indian Neck, Branford, where the ditching done by Mr. Bryan destroyed nearly all of the favorite breeding places, and where the depressions just described contained some wrigglers. On a rocky coast, breeding places may occur in pools under ledges where they are easily overlooked, but must be destroyed.

CHARACTERISTIC VEGETATION AS A GUIDE TO BREEDING AREAS.

The salt marshes are covered with characteristic grasses, sedges and rushes, which have been described in a previous report of this station.* Certain species are more or less confined to definite areas in the marsh, and are, therefore, valuable guides to mosquito breeding places when there is no water on the marsh. The breeding places of the salt marsh mosquito, *Culex sollicitans*, are nearly all found in the areas occupied by the plants herein mentioned in the order of their importance as indicating serious breeding areas. The accompanying diagram shows the arrangement of the plant zones where there has been no interference with nature in regard to the condition of the marsh and consequently the distribution of plants upon it. The chief species forming these mosquito breeding zones are as follows:

BLACK GRASS (*Juncus gerardi*).—This rush is usually confined to a narrow zone adjoining the upland, though sometimes when the drainage is good it spreads all over the marsh. This plant zone is the favorite breeding place of the salt marsh mosquitoes, and every depression in it capable of holding water yields an abundant supply. Fortunately, this rush is coveted by the farmer who drains the marsh to encourage its growth. Such marshes when well drained become sufficiently solid to permit the use of a mowing machine, but may yet contain breeding places brought about by natural or artificial causes such

* A. L. Winton, Forage Plants of the Salt Marshes of Connecticut, report of this station, 1889, page 233.

as the formation of slough holes, as described on page 287, the building of roads, the grading of land, etc.

SPIKE GRASS (*Distichlis maritima*).—This very conspicuous grass grows in areas of the marsh lower than are occupied by the black grass, usually forming a zone between the black grass and salt marsh grass, mixing with both; moreover, it grows in the depressed areas of the black grass zone, thus

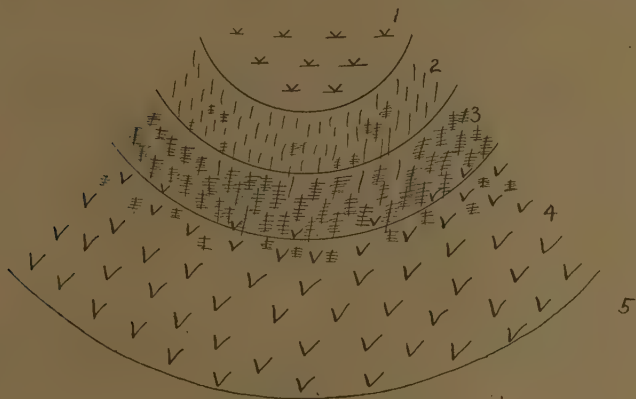


FIG. 23.—Diagram showing plant zones of the salt marsh. This scheme of arrangement may be modified so that the plants of any one zone may predominate and crowd out the others. 1. Upland, with "three-square" along the edge. 2. Black-grass zone, with spike-grass areas, and invasion of spike-grass along the lower edge. 3. Spike-grass zone, showing invasions of black-grass and salt marsh-grass. 4. Salt marsh-grass zone, extending to the water, showing invasion of spike-grass. 5. Water course.

making it an excellent guide to breeding places. It is necessary to drain all spike grass areas in the black grass zone, for they almost invariably contain rain water and breed mosquitoes.

RUSH SALT GRASS (*Spartina juncea*).—This is a grass that grows in the same areas as the black grass, often replacing it, and belonging in the same class so far as concerns mosquito breeding. The three plants just mentioned are shown on plate XVII.

SALT MARSH GRASS (*Spartina stricta*).—In the natural state this grass usually occupies the outlying low marsh area that is visited every day by tide water and fishes, consequently it is

to a great extent harmless or neutral; only when congested by the formation of slough holes or by human agency in building of roads, etc., does this become a serious breeding ground.

Sometimes cat-tail and "three square grass" invade the salt marsh sufficiently to assume importance.

From a survey of these grasses the real problem must be evident, namely, the drainage of all depressed areas in marshes occupied by these plants.

ARTIFICIAL BREEDING PLACES.

In addition to the fresh and salt marshes mentioned, hundreds of artificial breeding places were examined. Some of these were pools caused by filling, hoof prints in the ground filled with water, rain barrels, wells, tin cans and other receptacles too numerous to mention. At West Stratford, opposite the factory of Coulter & MacKenzie, a pond which was being filled with refuse from the city contained millions of wrigglers of *Culex pipiens*.

Our experience leads us to believe that the malarial mosquito *Anopheles* will breed almost anywhere if water stands long enough, and the larvae are protected from natural enemies.

Some of the most serious breeding places are formed by salt grass areas being cut off from their natural drainage by intercepting roads, dikes or other filling operations. In such cases the detached portion immediately becomes a potential breeding area which may become serious at any time if rain water accumulates and evaporates periodically. If the depressions in this area are deep enough to hold water permanently under ordinary conditions, fresh water species are likely to occur instead of the salt marsh species. Depressions of any kind caused artificially or naturally in the salt grass region are sure to become danger spots for the breeding of salt marsh mosquitoes if not deep enough to hold water permanently.

REPORTS OF COAST TOWNS.

During the summer one or more visits were made to every town on the coast of Connecticut and very careful examination was made of the marsh area with reference to the breeding places of mosquitoes. Somewhat detailed accounts of the ob-

servations are given in the following paragraphs, regarding certain towns. The conditions are nearly alike in the following towns, which may therefore be considered together: Greenwich, Stamford, Darien, Norwalk, Westport, East Haven, Clinton, Westbrook, Old Saybrook, Old Lyme, East Lyme, Waterford, Groton.

These places in the summer of 1904 had no very serious breeding places of the salt marsh mosquito, but had marsh areas which might, if neglected, breed mosquitoes. The marshes must be watched to find and fill or drain any depressions which form from time to time. Whenever improvements are made, as the building of roads, filling of land, etc., care must be taken that no undrained depressions are formed, as they will surely become breeding places. The farming of the marshes for salt hay has resulted in maintaining ditches which keep the marsh comparatively free from breeding holes.

A comparatively small outlay of time and money will make the marshes in the towns fairly free from breeding places. It is especially necessary to drain any stagnant places on the edge of the marshes between them and the high land.

To rid the marshes of mosquitoes, as distinguished from *breeding* places of mosquitoes, concerted action of all the towns is necessary because, as has been said, the salt marsh mosquito may travel far from his breeding place and a place which breeds none of them may yet be infested from a distant breeding place.

Nevertheless, the destruction of all breeding places in a town may be expected of itself to greatly abate the mosquito nuisance.

FAIRFIELD.

The marsh areas in Fairfield chiefly require simple ditches to connect the infested areas along the edge of the upland with tide water. North of the railroad the salt marsh is, after a short distance, replaced by the fresh-water marsh, where mosquitoes are never very abundant unless the marsh becomes congested by the interception of its natural drainage, and such a condition does not exist here.

The Bridgeport side of Ash Creek has some serious breeding places in the marsh adjoining, especially near the railroad. It will, of course, require the coöperation of the Bridgeport people

to make the work in Fairfield an unqualified success, though the breeding places for the salt marsh mosquito in Bridgeport, nearest to Fairfield, are nearly two miles from Fairfield's center of population.

The observations for this report were made July 11th, 15th and 16th, after a period of light rains and just after a perigee tide, consequently actual breeding was found only in such depressions surrounded by grass that admitted tide water and excluded fishes.

BRIDGEPORT.

The Bridgeport problem is easily solved because the breeding area is found almost entirely in the marshes along Ash Creek and Black Rock Harbor.

In West Stratford the most serious annoyance is a pond opposite the Coulter & MacKenzie machine shop, where the rain-barrel mosquito breeds steadily all the season, by millions. This pond is being filled slowly, but until the filling has been accomplished, oil should be applied every two weeks. A gallon of oil will suffice if properly applied with a spray pump.

STRATFORD.

The problem of getting rid of the salt marsh mosquito breeding places in Stratford township is practically solved. The community is entitled to congratulation on the excellent work done to exterminate mosquitoes. August 16th and 17th, 1904, the Stratford territory was examined. Nothing very serious was found.

MILFORD.

This township has a large marsh area, the condition of which is responsible for the presence of the great numbers of mosquitoes that appear every year in this vicinity. This marsh can, at comparatively small expense, be drained by the use of a ditching machine and be made mosquito proof. Simple ditches only are necessary. With the prevailing winds from the southwest and no other serious breeding area nearer than Fairfield, it is easy to see that to put a stop to the breeding in this large Milford marsh will greatly reduce the pest of mosquitoes in the town of Milford.

ORANGE.

The Woodmont marsh is in a fairly good condition, owing to the salt grass farming that has helped the drainage. The Savin Rock marsh had some mosquitoes breeding in it when examined on August 20th, but as a whole it is solid and well drained. If the danger spots are removed by putting in a few simple ditches, the marsh will be in an excellent condition and no longer the source of a nuisance.

The Old Field Creek or Sandy Point marsh was examined September 10th and found to be in a fairly good condition, owing to the salt grass farming which has resulted in much ditching and rather thorough drainage. West of Peck avenue, however, the marsh is of the fresh water type and a source of the malarial mosquitoes. In the West River marsh the breeding area is limited to a comparatively small area, owing to the salt grass farming that has put this marsh in good condition.

NEW HAVEN.

The following is reproduced with slight emendations from the report sent to the health officer of New Haven in August:

"In New Haven the most serious breeding places of malarial and other mosquitoes are found in the public parks and on other land owned by the city. These breeding places have been described and remedial treatment suggested, in a special report made to the New Haven Board of Park Commissioners on June 25, 1904, a copy of which is included herewith. Your attention is also directed to the remaining mosquito breeding areas in the vicinity of New Haven outside of the park system. In order to make the report complete geographically, a portion of Orange township is included.

The breeding places can be located by means of the numbers on the accompanying map.

The West River Marsh.

Between Chapel street and Derby avenue the condition of the marsh is much the same as between Chapel street and Edgewood avenue. From Derby avenue to Washington avenue the marsh is in a fairly well-drained condition, the danger spots lying in the pools east of the Boulevard and at No. 23 and No. 24; at No. 23 sparse breeding was detected early in the season; at No. 24 is a potential* salt marsh area where one choked ditch was breeding the salt marsh mosquito and another had fishes in it. This area, however, appears to be too flat to

* A potential area is a depression that will hold water and will breed mosquitoes, though not containing wrigglers when examined.

become very serious; at No. 25, between the Boulevard and the railroad, serious breeding was found in progress in the latter part of May. Below the New York Division of the New York, New Haven and Hartford railroad the West river marsh has the characteristic tendency to become potential in spots along the edge of the highland. The area where mosquitoes were actually found breeding is represented by a black border on the map. The oval area in the marsh, between Front and Campbell avenue, was of the potential type, stocked with fishes by the tide when examined May 25th. In the bank of the stream at No. 26, is a barrel that holds water and breeds *Anopheles*, the malarial mosquito.

Mill River Marsh.

✓This marsh is very well drained at the base of East Rock; its danger spots are at 27, 28, 29, 30, 31 and 32 (observations made June 1st-3d).

27 A few shallow depressions near ditches breeding salt marsh mosquitoes, the largest pool at this place being stocked with fishes.

32 Breeding sparse owing to ditches that need but small extensions to drain this area thoroughly.

28 This marsh area has potential breeding area in it that produce no serious broods of mosquitoes; it will take but a small extension of the ditches nearby to drain these areas. Along Willow street the refuse that is emptied on the bank is choking the ditch at the base of the embankment—a breeding area may be formed here in this way.

31 A fairly well-drained marsh, but the ditches must be extended to remove the breeding pools along the edge of the highland.

30 A serious breeding area completely cut off from its natural drain, a tide stream, by a cinder road. Ditches and a sluice, or filling, is here necessary.

29 A shallow pool over cinders with no mosquitoes in it, may never be dangerous.

Quinnipiac Marsh.

Fortunately, ditching to increase the yield of salt hay has removed such breeding areas as may have existed, and no serious problem confronts us here. The places that need attention are as follows. Observations made June 3d-8th.

33 Boat at Middletown avenue and Quinnipiac Creek: partially filled with water, and breeding mosquitoes.

34 Small neutral depression.

35 Cat-tail pond with *Culex* at the margin.

36 This marsh between the two railroads is potential: one depression had wrigglers in it, some pools with fishes, others neutral. Many dry potential areas had female mosquitoes over them, ready to lay eggs. All this could easily be drained.

37 This area is potential but no wrigglers were found, some pools had fishes in them.

38 Of the same type as 37.

39 Neutral, fishes in the ditches.

- 40 Brick yard with the ponds neutral and some stocked with fishes.
- 41 Cat-tail pond with a ragged edge, no wrigglers were found.
- 42 A cat-tail swamp with a central narrow stream and broad soggy margins extending from just north of Scheutzen Park tavern past the New Haven Gun Club to the railroad with a sluice under the railroad. Back of the Gun Club is a depression cut off from the main swamp. *Culex* larvae were found.

Marshes along the Quinnipiac River from Ferry Street to Morris Cove.

No breeding was detected except in Fort Hale Park (see Park Report) and at Morris Cove; still a season with frequent rains may develop breeding areas in the marsh between Fort Hale Park and Ferry street.

Morris Cove.

From Morris Cove comes New Haven's chief supply of mosquitoes when breeding is at its height, and here the condition is almost entirely of a salt marsh character. The most serious places are near the following numbers.

- 1-2 Woodland pools developing a woodland species that does not fly far.
- 3-3½ Typical salt marsh depressions where millions of salt marsh mosquitoes may breed.
- 4 Another typical salt marsh breeder.
- 5 and 10 Roadside pools of no serious character, present only in rainy weather.
- 11 Serious breeding area.
- 66 Breeding in typical potential areas.
- 67 Neutral salt marsh ponds.
- 60, 61, 62 Potential areas.
- 56 Covered with clear water (June 15th) though not entirely, soggy with sparse breeding.
- 57 Sparse breeding as in 56 (June 15th).

Other Breeding Places.

Receptacles around dwellings, business houses, etc., if exposed, will of course collect rain water and often become the source of great annoyance. Such places will have to be searched for by the sanitary inspector.

A MOSQUITO SURVEY OF THE NEW HAVEN PARK SYSTEM.*

Edgewood Park.

Very little breeding was found between Chapel street and Edgewood avenue, though it is hard to understand why, but just north of Edgewood avenue and east of the river were a few small pools filled with *Culex* larvae. (21) Apparently these pools were formed by the dredging of the river, the material being placed along the bank in such a way as to form a dam, preventing the surplus water from draining into the river.

* Sent to the New Haven Board of Park Commissioners in July.

These pools are probably not permanent ones, but exist in the early summer and in rainy periods long enough to breed mosquitoes. The judicious use of a few loads of filling material and the cutting of two or three short drains at slight expense would do away with these pools. The lagoon in the northwestern part of the meadow, (19) near Whalley avenue, was found to be a prolific breeder of *Anopheles* during August: sixteen larvae were taken at one dip with a ladle holding about a gill.

In the north portion of the meadow east of the river the conditions are also such that both malarial and non-malarial mosquitoes are breeding in the choked ditches, and water standing in the grass at the upper end of the artificial lily pond. (22) The land is rather low here, and a portion should be dredged out, and added to the meadow, thus increasing the pond and increasing the banks. The old ditches should be opened, and new ones cut wherever necessary. Further south a ditch crossing the meadow west of the river has also become choked, and larvae of the malarial mosquito (*Anopheles*) were quite abundant in it. This drain, as well as the lily pond where malarial mosquitoes breed, should receive immediate attention, and while we have not taken any levels in the meadow, we assume that the draining can be carried out without difficulty, as those parts of the meadow where the old drains are open are in good condition.

Beaver Park and Vicinity.

The area known as Hudson Park, which has recently been filled with ashes, is, of course, free from pools in which mosquitoes can breed. But the Beaver Swamp region (44) is the most serious breeding place of the *Anopheles* mosquito (the species which transmits malaria) in the vicinity of New Haven, and is a continuous breeder of both *Anopheles* and *Culex*. The streams contain running water and are free from mosquitoes except along the ragged edges where sheltered coves and depressions in the sphagnum and grass favor the accumulation of stagnant water. The whole swamp is water-soaked, with grass and sphagnum in the northern half and bushes in the southern half. Nearly all the ditches are choked and slimy and breed mosquitoes. The worst part of the region is between Munson and Fournier streets and is owned by the city, though perhaps not under the charge of your commission. Drainage would, doubtless, remove most of the stagnant water, and thus greatly improve the property and the public health.

East Rock Park.

A careful examination of the meadows at the base of East Rock shows them to be well drained. No serious breeding places were found on park property along Mill river.

West Rock Park.

The area along the river at the foot of West Rock was examined on June 18. Just below the Valley street bridge near the paper mills an arm of the river branching to the north extends nearly as far east as the foot of Emerson street. During high water in spring this area

is doubtless connected at both ends with the river, but when examined the water was stagnant, and without connection with the river. *Anopheles* larvae were abundant throughout this pool, and a few *Culex* larvae were found. This is certainly a serious breeding place at present, and a menace to health as long as it breeds malarial mosquitoes. A channel at the lower end properly graded would probably drain off this pool. Until this can be done the area should be kept well oiled. The breeding place can be located readily by means of the accompanying map. (See No. 20.)

Fort Hale Park.

This park contains a marsh area, the natural drainage of which has been interfered with by the continuation of Fort Hale Road along the shore east of the fort. The condition will be better understood by referring to the accompanying map. (45) The black spots mark the serious breeding areas where larvae of the salt marsh mosquito were found in abundance on June 13. The stream crossing the road has a good flow but does not properly drain the marsh area. Ditches connecting this stream with the breeding areas will be the most satisfactory solution of the problem here. On the northern side of the park and just over the boundary near Fort Hale Road, is another serious breeding area where ditches will be needed to carry off the water.

Other Parks.

Fort Wooster, Bay View, Waterside and Quinnipiac parks are situated on high land having good drainage and contain no mosquito breeding areas."

RECAPITULATION FOR NEW HAVEN.

Beaver Pond marsh, West River marsh and the fresh water portion of Sandy Point marsh in West Haven are the chief sources of malarial mosquitoes in New Haven. Next in importance are the small pools where *Anopheles* were found breeding, and finally the irregular edges of streams, the latter being least productive. The large lakes furnishing the city water supply are practically mosquito proof, owing to the clean margins and the presence of natural enemies; but eternal vigilance is even here the price of immunity and care must be taken that the aquatic plants do not grow too dense and thus create shelters in which mosquitoes may breed.

BRANFORD.

This report is based on observations made in the latter part of June during a period when the rainfall had been very light for six weeks, consequently actual breeding was not discovered

in many places that are surely potential.* Though the marshes were very dry it was possible to locate the most serious breeding places. The stream running around the northern and eastern portion of the village past the lock works and into Branford River was the chief source of mosquitoes in 1904. *Anopheles*, the malarial mosquito, was found everywhere. That portion of the stream between the lock works and the river was in very bad condition and malarial and rain-barrel mosquitoes were breeding abundantly. This region has since been drained and the condition much improved. In this vicinity the adults of *Culex perturbans* were also quite abundant from early in May until the middle of July, being troublesome on porches and verandas through the afternoon and early evening. Many specimens were captured in a corner of the brick foundation of a house back of some shrubbery. All attempts to breed this species were unsuccessful. The natural breeding place was not found, and we were not able to obtain eggs from females confined in gauze cages and fed on blood.

The salt marsh in the vicinity of Short Beach and Double Beach is comparatively limited and not in a serious condition as regards the breeding of mosquitoes.

In Pine Orchard the work of extermination has done much to control the salt marsh mosquito, but to complete the work it will be necessary to deepen the ditches already put in and to add more. The fresh marsh extending from the lake to north of the railroad is capable of breeding malarial mosquitoes, though none were actually found there.

The salt marshes of the vicinity of Stony Creek have such an excellent natural drainage that the task of exterminating the salt marsh species, that breed in this region, is comparatively easy and well within the grasp of the community. The freshwater marsh extending through the woods from near the shore to north of the railroad, will have to be treated to prevent malarial mosquitoes from breeding in it.

GUILFORD.

The breeding areas, for the salt marsh mosquitoes that are such a nuisance, are quite extensive in the marshes of the West and East Rivers in Guilford. At least half of the edge of the marsh adjoining the upland is depressed and holds rain water

* See note at bottom of page 293.

long enough to generate an inconceivable number of mosquitoes every favorable season. Aside from the breeding along the edge of the marsh there is nothing of importance. The marshes have ample streams running through them.

Near Sachem's Head the problem is more serious than usual, because the marsh areas are rather imperfectly drained by the remarkably narrow streams that pass through them. The marsh that could undoubtedly be drained into Island Bay has a decidedly inadequate drainage, owing to the narrow sluice in the form of a two-foot pipe that is laid under the railroad for its stream to pass through. This is an engineering problem, but throughout the remainder of the marsh areas simple ditches will evidently suffice. (See plate XIV, a.)

MADISON.

Madison has a greater mosquito problem than most towns along the coast, owing to the numerous breeding areas along the edge of the salt marsh adjoining the upland, and the unusual congested condition of the marsh between Hammonasset Beach and Hammonasset River. This Hammonasset marsh is in an exceptionally serious condition, owing to the insufficient drainage caused by lack of streams and the choking of one stream by a storm. Here a broad central ditch will be necessary to take the drainage through simple lateral ditches from the infested area.

NEW LONDON.

This township has small salt marsh nuisances at Fort Trumbull and Alewife Cove. At Fort Trumbull the salt marsh is somewhat cut up, especially by roads, thus forming potential areas. The solitary pool found at the time the observations for this report were made (September 5, 1904) was stocked with fishes, evidence that it is visited by tide water. This area will doubtless be filled in eventually, but in the meantime ditches and sluices should be put in to drain it and make the place free from breeding pools. Along Alewife Cove the marsh is naturally in a well-drained condition and needs very little, if any attention, unless the improvements in progress at Ocean Beach should cut off portions of the marsh from their natural drainage and cause serious conditions.

STONINGTON.

Here the really serious problem is confined to the large marsh area in the eastern part of the town. With this exception the marshes are in a fairly safe condition, owing to ample natural drainage and the salt grass farming.

RECAPITULATION.

In the foregoing pages we have pointed out the chief breeding places of mosquitoes on the salt marshes of Connecticut. Wherever improvements are made on the marshes, great care must be taken that no undrained depressions remain, for such are almost sure to become breeding places. Those portions of the marshes where salt grass is cut periodically are generally quite free from breeding places, and require but slight attention to make them perfectly safe.

In order to keep the salt marshes in a permanently safe condition it will be necessary to go over them each year and correct any imperfections that may occur.

It is important that adjoining property owners and adjoining towns should coöperate in the treatment of the marshes, especially where division lines are marked by streams with mosquito breeding areas along both sides. In such cases perfect results cannot be obtained without coöperation.

TREATMENT OF SALT MARSHES.

Simple ditching should be practiced in localities where the breeding area is not extensive or where the marsh is too soft to hold up a team. One method is to cut the sod with hay-knives or sharpened spades and then pick it out with forks. Some use spades alone. The ditches need not be more than eight inches wide and should be placed from 100 to 150 feet apart, according to the condition of the area drained; in very soggy areas it may be necessary to bring the ditches closer than 100 feet. Ditches of this kind will last for at least three years and perhaps longer without any attention except to keep them clear of debris.

The following information was issued in July in the form of a circular illustrated with some of the photographs used in the plates of this report.

USEFUL FACTS ABOUT DESTROYING THE SALT MARSH MOSQUITO.

In draining ordinary salt marsh land, an Italian laborer can dig per day of ten hours at least 100 feet of ditch 18 inches wide and 18 inches deep.* His wages are from \$1.25 to \$1.50.

The ditching squad should contain from seven to ten men. The foreman should carry a ladle to dip water from the pools to see if wrigglers are present and in what numbers. By doing this he will soon become familiar with the sort of places where mosquitoes breed and those which are safe.

If a mosquito survey of the region has been made, the serious breeding places will have been indicated upon a map, and this will be found a useful guide; still a little experience enables one to recognize these places by their appearance.

The worst breeding places are usually the brown depressions near the edge of the highland. These bare places look as if scooped out and the brown color is due to the rotted condition of the soil. Water stands in these areas after each rain. Such places must be connected with tide water by the ditches and should receive first attention, even if dry, because after each rain they may breed mosquitoes. Drains can then be cut to the pools having the most wrigglers.

After these worst places have been treated, all standing water near the edge of the highland must be tested again and again and ditches cut to drain all pools wherever wrigglers are found.

Fish-stocked pools near the edge of the marsh, though usually safe, occasionally become dry. The fish are killed and when filled again with water a mosquito breeding place is formed. This makes it quite necessary to test from time to time all ponds near the edge of the marsh even though they are usually safe. Clear ponds reached by tides and ponds stocked with fish are as a rule safe for all time.

After the ditches have been cut in the marsh they should be tested, and all imperfections removed that would permit the breeding of mosquitoes in them. Ditches must be sufficient to drain completely, or open to the tide all breeding areas. The ditches will need cleaning out at least once each year to prevent them from becoming clogged by the growing vegetation or flood debris.

* Report of Experiments, Lawrence, L. I., Board of Health.

By constantly examining the marsh and by cutting ditches wherever necessary, exemption from mosquito breeding will soon follow, and the results will be of lasting value.

Most ditches need not be more than from 8 to 12 inches wide, but a good depth is necessary through nearly the entire length. A satisfactory way is to cut the sides with an ordinary hay knife and remove the sod with a potato hook, as is shown in the accompanying illustration. (Plate XV, b.) It will facilitate the work if the tall grass is cut with a scythe before the ditches are started. Much depends upon the thoroughness of the work, and no loop hole should remain where a solitary mosquito can breed.

Where the area to be ditched is so extensive as to require the expenditure of \$500 or more, and where the marsh is sufficiently solid, a ditching machine should be employed.

DITCHING MACHINES.

In New Jersey where extensive work has been conducted on large marsh areas, a ditching machine has been found economical and satisfactory.

Prof. J. B. Smith reports that ditches can be dug for about one cent per running foot by the True Ditching Machine, which has been used extensively. In New Jersey narrow ditches from four to eight inches wide, which preclude the growth of vegetation, and from two to three feet deep, have been found much more satisfactory than wide and shallow ones, which soon become choked with plant growth or debris. The narrow ditches, even if they become closed at the top, keep open at the bottom and for several years are effective in draining the land.

The True Ditcher is made to be operated by hand power, and in larger sizes by steam or gasoline engines. Formerly the manufacturers have taken ditching contracts on large areas of salt marsh, and the machine was not for sale; but recently we have been informed that the manufacturers are going out of the business and wish to sell the patent rights for this machine. Shown on plate XVI, b.

The Buckeye Traction Ditcher is the name of another machine which the manufacturers claim will do satisfactory work on marsh land that is not too soft. We are not aware, however, that any tests have actually been made with this machine on salt marshes.

MOSQUITO CONTROL IN CONNECTICUT.

There seems to be a reluctance on the part of many to take up the work of mosquito control. This we believe is due largely to a lack of confidence in the results to be attained.

The application of oil to breeding areas has been practiced in some places, but oil to be effective must be applied to every brood, which means every two weeks in a favorable season. At the end of the season the locality is no better off for having been treated with oil than it was before. Of course, oil can, and should, always be used as a makeshift until the lasting work such as ditching or filling, which are the only rational means, has been accomplished.

A few years ago one of the worst mosquito breeding places in Connecticut was undoubtedly the extensive Stratford marsh lying east of Bridgeport. This marsh was elaborately ditched and diked by a land improvement company, the work being in charge of Mr. W. R. Hopson of Bridgeport. The number of mosquitoes was noticeably reduced by the improvement and Mr. Hopson was rewarded by the people of Stratford. This large marsh is now almost entirely free from breeding places, and produces a much better quality of salt hay than formerly.

At Indian Neck in Branford, Mr. W. A. Bryan has been working systematically since 1900 to reduce the number of mosquitoes. Mr. Bryan is proprietor of the Montowese House, a summer hotel, and he realizes that destroying the mosquitoes will improve his business. At first Mr. Bryan used oil on the breeding pools, but during the past two years draining has been practiced, thus permanently abolishing them. Mr. Bryan has been aided in this good work by some of his neighbors and by the Branford Board of Health.

The most serious breeding place of malarial mosquitoes in Branford has been practically destroyed during the past season by the drainage of the choked marsh area just east of the village. This was brought about chiefly through the efforts of Dr. C. W. Gaylord of the local health board.

The Improvement Association of Pine Orchard in the town of Branford has systematically drained considerable marsh area during two seasons, expending nearly \$300 each season on the work. Oil has also been used, especially on the inland swampy areas.

In past years considerable excellent work has been done by Mr. Sturgis, in filling the inland pools of Fairfield.

Oil has been used to combat the salt marsh mosquito at many places, where through lack of persistent effort it has given only temporary benefit.

The natural growth and extension of cities and towns, and the general improvement of the land, have been responsible for the destruction of many mosquito breeding places throughout the inland areas.

At Hartford the Board of Health expended about \$80 in 1903 in oiling certain pools in the South Meadows where mosquitoes were supposed to breed. This work must have been satisfactory for early in the summer of 1904 the common council appropriated a sum of money not to exceed \$250 for the work, placing the appropriation at the disposal of the Board of Health. We believe this to be the first case in Connecticut where a municipality has appropriated money for the control of the mosquito pest.

In Keney Park, Hartford, considerable work has been done in draining, filling and oiling certain natural depressions called "pond holes" or "sink holes," where mosquitoes were breeding. This work has recently been in charge of Mr. W. F. Schults, and through the courtesy of Mr. G. A. Parker, Superintendent of the Park, we have been furnished with a detailed account of the operations.

COÖPERATION AND COMPULSION IN MOSQUITO CONTROL.

While much can be done by individuals in the work of mosquito control, the results are so far-reaching, especially in the coast region, that community of effort should be directed in its behalf. Generally speaking, it should be the duty of every property owner or tenant to prevent mosquito breeding upon the property of which he has charge. Possibly some legislation may be necessary in order to make action compulsory in the worst cases. Apparently the only relief that can now be had by statute provision comes through the local health officer. That he has power to act no one will dispute; but the cost of the work in some cases should properly be borne by the community, town or city, and not wholly by the owner. The health

officer, too, will feel more justified in acting in cases of malarial species, than if only a pest is complained of: but there should be some way of reaching and controlling mosquito breeding even if the malarial species is absent. There is no reason why any community should be continually annoyed each season, when often with the expenditure of a small amount of money it can be abated locally.

The salt marsh species, as already stated, are chiefly migratory forms. For this reason they assume a peculiar importance which is augmented by their intense breeding, wherever conditions are favorable on the salt marsh—millions developing in comparatively small pools. Their habit of migrating as far as thirty miles from their breeding places makes local action result in palliation rather than in absolute control, where the locality is so situated that mosquitoes can come from neighboring marshes and makes it obvious that coöperation all along the coast is necessary before this nuisance can be thoroughly abated.

MOSQUITOES AFFECT PROPERTY VALUES.

The mosquito question concerns not only the health and comfort of every man in the community, but affects also his business interests. The mosquito nuisance is the only disadvantage of the beautiful shore region of Connecticut. The salt marsh species, which breed in certain stagnant water areas of the salt marsh, often make life almost unendurable near the shore. The persons owning shore cottages, summer hotels, boarding houses and places of amusement should be deeply interested from a business standpoint in the question of mosquito control. Property values are higher, and summer visitors more numerous, where mosquitoes are few. Not only is property increased in value on account of summer visitors, but the land bears better crops of salt marsh grass where properly drained. In many cases this increase more than pays for the cost of the draining work. It is well known that marsh land is fertile, and will produce good crops under the proper treatment, if we can get rid of some of the water. The best celery fields in the country were once fresh water swamps. Many of the mosquito breeding areas which are now serious can be done

away with completely and permanently at slight expense. Every dollar judiciously expended in permanent work will mean millions less of mosquitoes not only for a season, but each year for years to come, as the simple ditches will remain open usually for a long time. Even a ten dollar ditch will often drain a breeding area capable of producing more than ten million mosquitoes in a wet season.

The mosquito survey described in the foregoing pages shows that a large proportion of the salt marsh mosquitoes breed on a small area of the salt marshes, and the maps which we have placed in the hands of the shore town health officers show just where these breeding areas are, while the reports explaining them tell what treatment seems advisable. Duplicate maps and reports can be seen at the Station, where information about the region will be freely given to those interested in taking up the work of mosquito control.

No one can overestimate the benefits to be derived from this work and no community need hesitate to start it, for the outlay of a comparatively small amount will at once do away with the worst part of the problem in most localities.

EXPERIMENTS WITH COPPER SULPHATE.

Copper sulphate is now recommended and used for the destruction of algae in reservoirs and lakes. It has been advised for use against mosquitoes, chiefly because it destroys the organisms upon which the larvae feed. There is considerable misapprehension, however, on this point and we find many persons who believe that the larvae are killed directly by the copper sulphate. To have a direct action it must be employed in a much stronger solution than is commonly used in potable water supplies, namely 1 part in 100,000. A few tests were made with this chemical substance and its action upon mosquito larvae.

At 10 A. M. on May 13th 1 gram of copper sulphate was put into 3 ounces of water containing wrigglers of *C. cantator*. The larvae died off gradually so that no living ones remained at 9 A. M. on May 16th; most of the pupae matured, only a few died.

On July 30th 1 gram of copper sulphate was added to 60,000 grams of water containing all sizes of wigglers but no pupae. On August 2d apparently no change had taken place in the barrel, except the appearance of one pupa. At 8 A. M. on August 4th two pupae had formed and about 30 per cent. of all sizes of the larvae were dead. On August 5th the experiment barrel presented no appreciable decrease in population. On August 6th there were no pupae, no egg boats and an apparent decrease in larvae of all sizes. When examined August 8th there was found one egg boat and two pupae; otherwise conditions unchanged.

From these experiments it is evident that copper sulphate used in the proportion of 1 part in 60,000 does not wholly check development or entirely prohibit breeding. Similar tests were made with larvae of *C. pipiens*.

EXPERIMENT WITH SHRIMPS.

Three shrimps were brought to the Experiment Station from the salt marsh in a jar with some larvae of salt marsh mosquitoes. They were apparently eating the larvae, and in order to determine their effectiveness along this line, the following tests were made.

On August 2d nine wigglers were put into the jar with the three shrimps. Though at the time a pair of the shrimps were in coitu all started forth at once to seize the wigglers. The single specimen caught a wriggler, as did one of the pair. The larvae was held head first between the mouth and the legs of the shrimp and the anterior half eaten in about five minutes; then the shrimp dropped the remainder and set to work cleaning itself, during which operation the shrimp remained curled up in one place without moving its appendages. At all other times these appendages seem to be constantly in motion. In ten minutes the shrimp had eaten the remaining portion of this larva.

On August 6th one larva remained in the jar with the shrimps. That shrimps aid in reducing mosquitoes is evident, but their structure and small capacity does not enable them to destroy very great numbers of the larvae.

EXPERIMENTS WITH A YOUNG PIKE FISH (*Lucius americanus*).

On May 16th about fifty *Anopheles* larvae, only a few of which were fully grown, were put in a jar containing two ounces of water with a small fish, less than an inch in length. Two days later all *Anopheles* larvae had been devoured and the fish was apparently dead, doubtless from overfeeding; however, it recovered. On May 21st twelve *C. cantator* larvae were put into the jar with the fish. On the 23d only three larvae remained and the fish was active. All had been devoured on May 25th.

ACKNOWLEDGMENTS.

We desire to here express our appreciation of the courtesies shown by various individuals who have given information that aided our work. On July 23d Mr. Viereck visited Lawrence, Long Island, and was shown the drained marshes there by Mr. E. M. Bentley, President of the Board of Health, who has had charge of the work. Mosquito breeding at Lawrence has been almost completely done away with, by the draining of the extensive marsh areas, and much valuable information was given us by Mr. Bentley regarding the width and effect of ditches, their durability, etc.

To Mr. W. A. Bryan of Indian Neck, Branford, who has had experience in ditching work, and Mr. F. H. Hart, who has been connected with the important work at Pine Orchard; to Mayor Crittenden of Middletown; to Mr. S. H. Wheeler of Fairfield; to the Hartford Board of Health and to Mr. G. A. Parker, Superintendent of Keney Park, Hartford, we are indebted for the many courtesies shown and the information given regarding the local conditions, and to all parties mentioned we here express our thanks.

We are especially indebted to Dr. L. O. Howard, Chief of the Bureau of Entomology for the identification of some of the species by Mr. Coquillett; to Dr. E. P. Felt, State Entomologist of New York, who has examined all of the specimens of mosquitoes in our collection, and the keys printed in this report.

SUMMARY.

The recent discoveries show that certain kinds of mosquitoes are responsible chiefly, if not wholly, for the transmission of certain human diseases such as malaria, yellow fever and filariasis (elephantiasis). At the present time over four hundred species of mosquitoes are known in the world, and over sixty occur in the United States. Twenty-two of these have been found in Connecticut.

A mosquito survey of the state was undertaken in 1904 to learn what species occur in Connecticut, where they breed most abundantly, and what means will be found most useful in abating the nuisance. Mosquitoes do not breed in grass, as many suppose, but only rest and hide there. Water is absolutely essential, and in it the larval and pupal stages are passed. The development of a brood requires only about a week in warm weather. The wrigglers are obliged to rise to the surface every few minutes to get air.

Anopheles, the malarial mosquito, lies horizontally at the surface of the water when breathing, while *Culex* larvae hang with heads downward. The regions about Hartford, Middletown and Cheshire were inspected, and the entire salt marsh region extending along the coast from New York State to Rhode Island was examined during the summer. The breeding places were marked upon maps, and a map of each town with a report of the breeding places and recommendations for abolishing them were placed in the hands of the local health officer. Duplicate copies of maps and reports were deposited in the office of the Secretary of the State Board of Health at New Haven.

In the inland region the malarial mosquito *Anopheles*, and the house or rain-barrel mosquito, *Culex pipiens*, are the important species. Connecticut has over thirty-four square miles of salt marsh, most of which is well drained and free from serious breeding places; such places occur, however, next to the upland, around the edges of many marshes, and the building of roads, etc., across the marshes has in many cases interfered with natural drainage so as to form breeding places. Slough holes are formed from year to year, and become mosquito breeding places. Serious breeding areas may often be detected by the character of the vegetation even when not filled with water.

Culex sollicitans and *C. cantator* are the most abundant mosquitoes near the coast. They breed on the salt marshes, and migrate inland for several miles. The malarial and other mosquitoes breed around the salt marsh in fresh or brackish water.

The natural enemies of mosquitoes are fishes which live upon animal food, and predaceous aquatic insects, like water beetles and dragon flies.

Remedial measures practiced against mosquitoes consist in abolishing, where possible, all pools or receptacles in which they can breed. Receptacles should be removed or screened, pools or other standing water in the ground should be drained or filled. Pools that cannot well be drained or filled should be stocked with fish. Many permanent

pools contain aquatic insects which feed upon mosquito larvae. Narrow and rather deep ditches cut in the salt marshes in the proper places will drain the soil and be open to the action of the tides, both of which will tend to do away with mosquito breeding. In large marshes a ditching machine can be used, but in small ones the ditches can be cut by hand. Coöperation should be practiced in the treatment of the salt marshes, as adjoining towns and villages are affected, and in some sections the marsh land is owned by many individuals.

All houses should be screened to keep out mosquitoes. Kerosene or light fuel oil may be spread upon the surface of the water to kill the wrigglers, but this is a temporary expedient, and should be repeated each ten days.

Considerable draining work has been done in the state, especially at Stratford, Indian Neck and Pine Orchard, Fairfield and Hartford. Mosquito control is no longer simply experimental. Plenty of demonstrations have been made to show its feasibility, and health boards, individuals and communities are taking up the work.

Drainage greatly improves salt marsh land for farming purposes. Property values increase around summer resorts, and summer visitors become more numerous where mosquitoes are controlled.

Details of the survey may be found in the foregoing pages.

The Station will furnish information regarding the breeding places, life histories of mosquitoes, and best methods of treatment for particular localities, to individuals and communities planning to take up the work of mosquito control. So far as is possible it will, upon request, send a specialist to examine areas suspected of breeding mosquitoes.

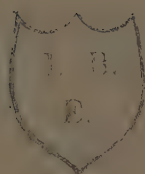


a. This depression, formed by an uprooted tree, filled with rain water and was breeding *Culex Canadensis* in May.



b. This depression in the ledge contained water and was breeding *Culex cantans* by the million early in the season. Near Morris Cove.

FRESH WATER BREEDING POOLS.



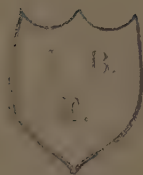


a. View near the Cedar Hill railroad station. The natural drainage has been cut off by the building of a road, and a serious mosquito breeding place has been formed.



b. View in Beaver Swamp, New Haven. Both *Culex* and *Anopheles* breed here abundantly.

FRESH WATER MOSQUITO BREEDING AREAS.





a. This pool contained an abundance of larvae of *Culex pretans* in May.
Near Wawarme Ave., Hartford.



b. Ashes and other material dumped along Wawarme Ave., which might be used
to fill the pool shown in a. The white stake is shown in both pictures.

MOSQUITO BREEDING POOLS AT HARTFORD.

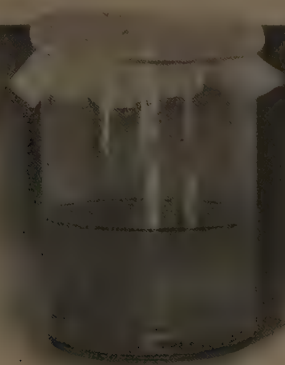
"WRIGGLERS"
MOSQUITO LARVAE

Watch them! They will develop into Mosquitoes

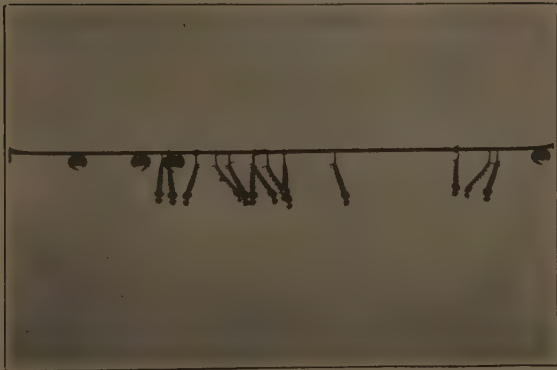
*Taken in the pools of the salt marshes in the
vicinity of New Haven*

They breed ONLY in water and CAN be exterminated

Exhibited by the Connecticut Agricultural Experiment Station
Entomological Department New Haven Conn



a. Jar for exhibiting mosquito wrigglers.



b. Mosquito wrigglers. Larvae and pupæ as they appear
at the surface of the water to get air.

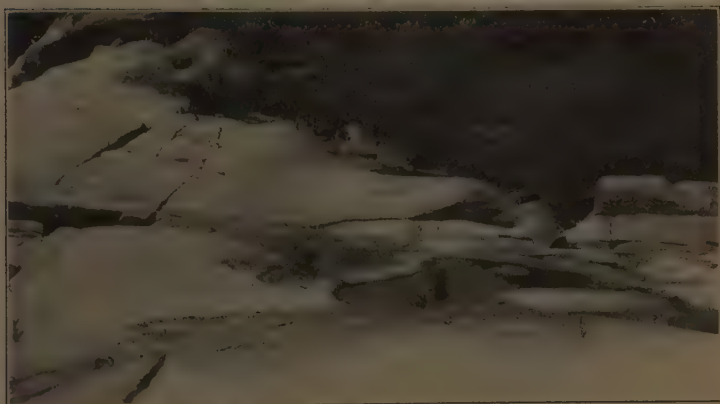




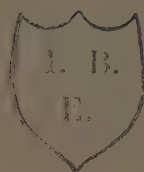
a. Salt marsh not well drained. Hay stacks are standing in water which can escape only through a choked drain leading at first directly inland.
View looking seaward. Near Leete's Island, Guilford.



b. Wing of a mosquito, showing scales.



c. This small depression in the ledge was filled with rain water containing wigglers of *Culex atropalpus* at Double Beach, Branford, in July.





a. Pool near edge of salt marsh where mosquitoes were breeding by the million.
Near Morris Cove, New Haven.



b. Simple method of cutting ditches through a marsh. The sides are cut with
hay knives and the turf pulled out with a potato hook.



a. A typical breeding place for the salt marsh mosquito is where water stands in the grass on the marsh. Wrigglers are out of the reach of their natural enemies. View back of Morris Cove.



b. The True Ditching Machine at work on a New Jersey marsh. (After Smith, Report on New Jersey mosquitoes.)

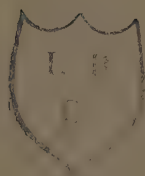
THE SALT MARSH: MOSQUITO BREEDING AREA AND DITCHING MACHINE.





1. Rush Salt Grass *Spartina juncea*. 2. Black Grass *Juncus gerardi*.
3. Spike Grass *Distichlis maritima*.

SALT MARSH PLANTS WHICH ARE GUIDES TO BREEDING PLACES.



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